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Chemistry variation during purging Of alluvial wells At Los Alamos National Laboratory

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Los Alamos
NATIONAL LABORATORY

Shallow alluvial well located in Los Alamos Canyon. Photograph by Eric Riebsomer.

Chemistry Variation during Purging of Alluvial Wells at Los Alamos National Laboratory

by

Eric Riebsomer

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Dr. Michael Campana, Chair

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Committee Approval

The Master of Water Resources Professional Project Report of **Eric T. Riebsomer** is approved by the committee:

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Abstract

The purpose of this study is to determine how chemistry results vary from shallow alluvial wells during purging. We sampled seven shallow alluvial wells at four different purge volumes. Drawdown and the field parameters pH, DO, EC, ORP, and turbidity were collected to determine stabilization trends for each well. During each sampling event, water samples were collected after purging one-half, one, two, and three well bores, and later analyzed for metals (unfiltered), and major cations and anions (filtered).

Drawdown and turbidity were the only field parameters measured that affected the results. LAO-0.7, MCO-5, MCO-7, and CDBO-6 each had drawdown in excess of 0.3 ft, which, in these cases, seemed either to increase turbidity readings or prevent stabilization. For five of the seven wells, chemistry analyses show the only consistent changes between samples were in Al and Fe, which followed changes in turbidity. The two exceptions were MCO-5 and CDBO-6, which had more drawdown. The major cations and anions showed little variation during purging. For the field parameters, pH and EC showed no change, while temperature, DO, and ORP were not representative of the formation water.

In the end, this study suggests drawdown has the main effect on turbidity and turbidity has the main effect on sample quality. Therefore, when drawdown is minimal (around 0.3 ft), or in some cases a little more, and turbidity has stabilized, a representative sample may be collected after purging only one well bore. Otherwise, sample collection might require purging three well bores.

Introduction

Sampling protocol for the surveillance program at Los Alamos National Laboratory (LANL or the Laboratory) allows for collection of water quality samples after purging three well bore volumes of water, or after water quality indicator parameters have stabilized (Risk Reduction and Environmental Stewardship-Water Quality and Hydrology Group Sampling Procedure, 2001). Purging the three well bores is the default, though it may create significant water waste and can take significant time for the sampler.

Over the past 10 years LANL has modified its shallow groundwater sampling methodology to generally use dedicated bladder pumps to sample at lower pumping rates. These changes lead to less disturbance of water in the well, so samples are less aerated, have lower turbidity, and are likely representative of formation water at an earlier stage during purging (Robin & Gilham, 1987; Powell & Puls, 1993; Puls & Barcelona, 1995).

Studies at other DOE sites have documented how water quality, in particular, constituents of concern, change during purging (Paquette, 1999). The result is that samples are collected after less purging.

In this study I will show how water quality from shallow alluvial wells varies during purging, and that samples may generally be collected after purging less than three well bores. This study establishes a trend of parameters and chemistry results for each of the shallow wells sampled.

The following sections will describe background information, including low-flow purging, current sampling procedures, and the study site. Followed by the sampling setup and procedures used. The final section of the paper presents the way chemistry changes at different purge volumes, and trends in the field parameters.

Background

Low-Flow Purging

It is general practice to purge monitoring wells prior to sampling. Purging allows for collection of a sample that is representative of the formation around the well bore, rather than water affected by chemical processes near or in the well (Powell and Puls, 1993). Historically, the industry standard for purging has been three to five well bore volumes of water. The standard was based on early recommendations in the groundwater monitoring literature (Robin and Gilham, 1987), and reflects concern over sampling of stagnant water in wells with significant height of water in the casing above the screen. Studies have shown certain geochemical changes can occur if water stands in a well for extended periods of time. These changes are due to atmospheric exposure at the top of the water column, leaching or adsorption to the casing material, and surface infiltration (Powell and Puls, 1993). In addition to these, various microbiological changes can change the water chemistry (Powell and Puls, 1993).

Low-flow sampling refers to the velocity with which water enters the well screen due to pumping (Puls and Barcelona, 1995). Lower flow reduces the amount of disturbance by water entering a well. The result is lower turbidity and less aeration of samples by sampling at a flow rate closer to natural groundwater flow in the neighboring formation. Low-flow sampling also draws water directly from the formation rather than disturbing the standing water in the well bore. Such sampling after fewer than three well bores will often yield a sample representative of the formation water (Robin and Gilham, 1987).

Low-flow sampling is becoming more accepted by the environmental community, including regulators. The New Mexico Department of Environment (NMED) has recently published a position paper providing recommended criteria for collecting groundwater samples when using the low-flow technique (Hazardous Waste Bureau, 2001). The paper gives guidance on well construction, dedicated pumps, drawdown, and stabilization of parameters. This study used the NMED recommendations (Table 1) for determining appropriate drawdown and when parameter stabilization has occurred. Note there are no criteria for oxidation-reduction potential (ORP) stabilization listed. ORP is a parameter that represents the oxidizing or reducing properties of water. Stabilization occurs if the parameter does not change more than the range given in Table 1 over three consecutive readings taken every 5 minutes. Low-flow purging is considered (by EPA and NMED) to be a purge rate that is 1.0 liter per minute (LPM) or less.

Table 1. Stabilization criteria for the field parameters (Hazardous Waste Bureau, 2001)

Parameters	Stabilization Criteria
pH	± 0.5
Specific Conductance	± 10%
Temperature	± 10%
Dissolved Oxygen	± 10%
Turbidity	< 5 NTU* ± 10%
Purge rate	< 1 LPM
Drawdown	Not more than 0.3 ft*

* Turbidity of < 5 and drawdown of less than 0.3ft is ideal, but it may vary based on site conditions.

Groundwater Sampling at LANL

Groundwater quality monitoring has been part of environmental surveillance at LANL for 50 years. Such monitoring tracks water quality within the three modes of groundwater occurrence in the Los Alamos area. The three modes are: 1) water perched in shallow alluvium in canyons, 2) perched groundwater at intermediate depths (100 to 800 feet), and 3) the regional aquifer for the Los Alamos area, at a depth of 600 to 1200 feet (ESP, 2001).

Starting in the early 1990's, the method for sampling shallow alluvial wells at the Laboratory changed from the use of bailers, or submersible pumps, to dedicated bladder pumps. Installation of dedicated bladder pumps meant two things: 1) pumps are permanent, creating less well disturbance when sampling, and 2) pumps can purge at rates less than 1 LPM.

The sampling procedure for the Environmental Surveillance Program allows for collection of samples after purging three well bore volumes of water or after water quality indicator parameters have stabilized (RRES-WQH, 2001). Low-flow sampling may allow collection of a representative sample with less purging, saving time in the field.

Study Site

The study took place in Los Alamos Canyon, Mortandad Canyon, and Cañada del Buey. The alluvium within the canyons is similar, consisting of sand, gravel, cobbles and boulders, mostly derived from the weathering of Bandelier Tuff (Purtymun, 1995). Surface water infiltrates into the alluvium, forming small bodies of perched groundwater.

The alluvium may be up to 70 ft thick, and saturation varies in extent with seasonal influence of evaporation and runoff. Surface flow in the canyons is mostly supplied by intermittent storms during the summer rainy season (July-September), snowmelt runoff, and effluent discharges from facilities located around the Laboratory. Thus, surface water within the canyons is variable, leading to variability of water in the alluvium.

The drainage area for Los Alamos Canyon within the Laboratory's boundary is approximately 10.6 mi^2 above SR-4 (Purtymun, 1995). We sampled three observation wells in this canyon. There is some perennial surface water in the canyon west of the Laboratory. The alluvium ranges in thickness from 8 ft to 19 ft (Purtymun, 1995).

Mortandad Canyon has a smaller drainage area than Los Alamos Canyon (1.8 mi^2)(Purtymun, 1995). We sampled three wells in Mortandad Canyon. The thickness of the alluvium ranges from 8 ft at the upper wells to 72 ft at the lower wells, (Purtymun, 1995).

Cañada del Buey has a drainage area of 1.3 mi^2 on Laboratory property. We sampled one well in this canyon. The thickness of the alluvium is approximately 3.6 ft to 15 ft (Purtymun, 1995). A map of the canyons with sample locations is shown in Figure 1.

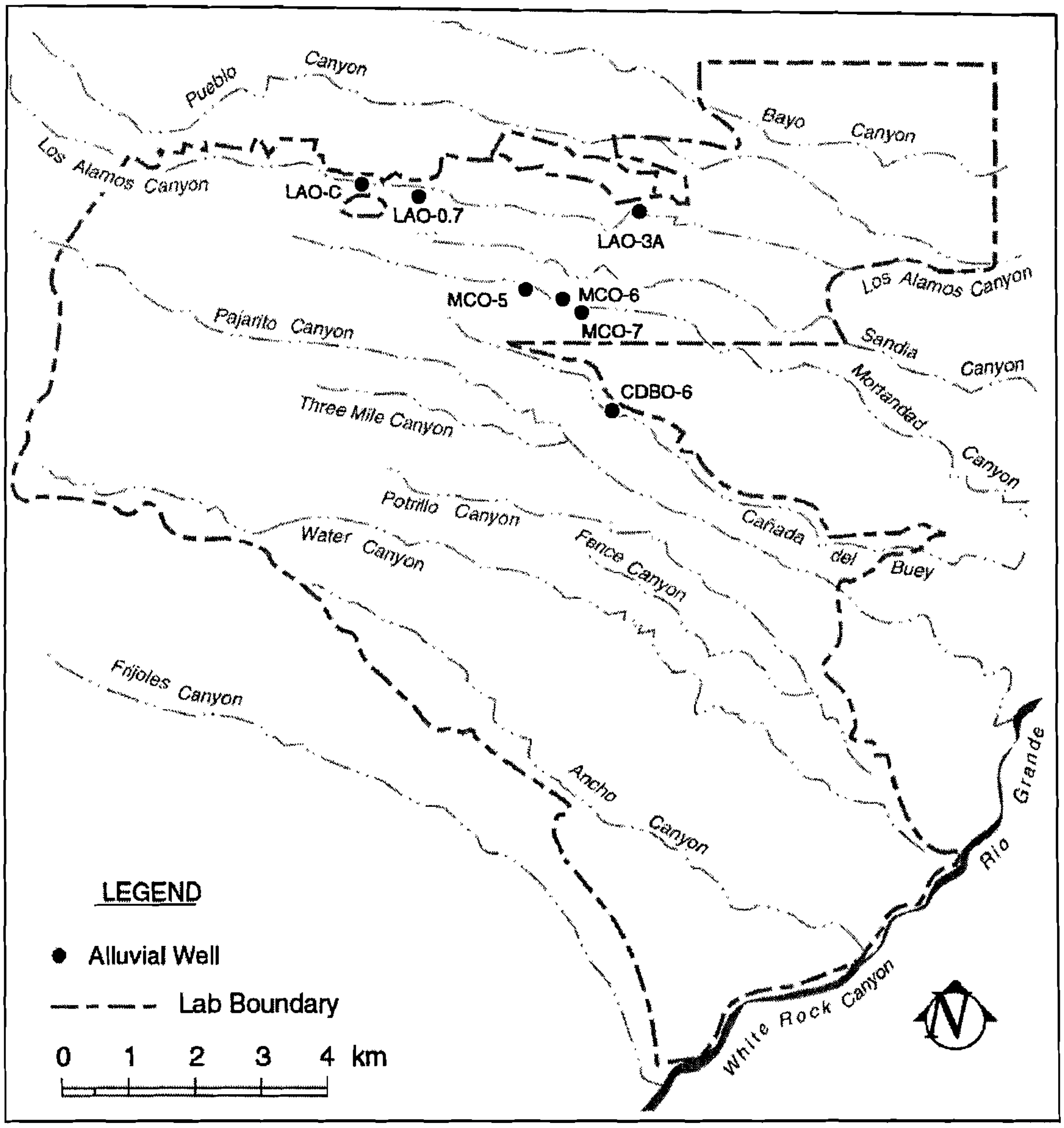

Figure 1. Map of alluvial wells sampled in this study.

Methodology

Well Characteristics

For this study I sampled seven shallow alluvial wells located within three different canyons on Laboratory property (Table 2).

Table 2. List of wells sampled.

Well	Completion Date	Diameter (in).	Completed Depth b.l.s[1]. (ft)	Water Level b.l.s (ft)	Height of Water in Well b.l.s (ft)	Measuring Point a.g.l[2]. (ft)
CDBO-6*	1/1/1992	2	49	37.81	11.19	1.5
LAO-C	8/1/1970	3	13	3.15	9.85	1.5
LAO-0.7	1/1/1993	2	25	13.38	11.62	1
LAO-3A	9/14/1989	2	14.7	9.25	5.45	.43
MCO-5	10/1/1960	3	46	27.65	18.35	1.95
MCO-6	3/1/1974	4	47	40.46	6.54	2.34
MCO-7	10/1/1960	3	69[3]	45.16	10.34	1.24

*CDBO-6 has a 5 ft sump, and the bottom of the bladder pump is set to 1 ft above the sump
1. b.l.s.-below land surface
2. a.g.l.-above ground level
3. Depth used to determine height of water was 55.5 ft; there is an obstruction in the well at this level.

The wells were constructed between 1960 and 1993. They were drilled with a 4.5-inch auger and either a 2-inch, 3-inch or 4-inch plastic pipe was set in the hole and sealed at the surface with cement. Newer wells have gravel packs around the screen, while older wells were sealed with drill cuttings. Lastly, a cement pad was placed around the wellhead and the wellhead secured with a padlock (Purtymun, 1995).

Measured Field Parameters

The field parameters pH, temperature, electrical conductance (EC), dissolved oxygen (DO), oxidation-reduction potential (ORP) and turbidity were measured during sampling. Of these parameters, DO, ORP, and turbidity are the best indicators of stabilization. DO and ORP are the hardest to measure because of practical issues with sample collection- in particular, keeping air out of the system. Electrical conductance, pH, and temperature are less sensitive indicators of stabilization (Powell and Puls, 1993), but offer information pertaining to the characteristics of the water at each well.

Two different methods were used to compare the results. The parameters pH, temperature, electrical conductance and turbidity were manually collected using individual meters, and ideally collected as close to every five minutes as possible. These parameters, with the addition of DO and ORP, were also collected using the Hydrolab Datasonde4, a flow-through measuring device. The Hydrolab was used to obtain water quality parameter readings every 30 seconds. Drawdown was measured throughout the sampling event using a Solinst depth probe.

Sampling Setup

A cartoon of the sampling setup can be seen in Figure 2. The sampling setup consisted of one-half inch I.D Teflon tubing, a Teflon tee with a pin valve, a piece of garden hose for the relief tube, the Hydrolab DataSonde4 multi-probe, and the Hydrolab Surveyor4 data logger. The DataSonde4 was placed in a fabricated tripod to allow mobility and stability of the instrument. To have a dedicated sample port separate from the water going into the Hydrolab, we used the Teflon tee with the pin valve to allow us to sample upstream of the Hydrolab. We used a separate tee for each well and decontaminated with alconox and DI water for each use. The relief tube is where air was allowed to travel into the flow-through cell when the sample port was opened. All sample tubing was used only once.

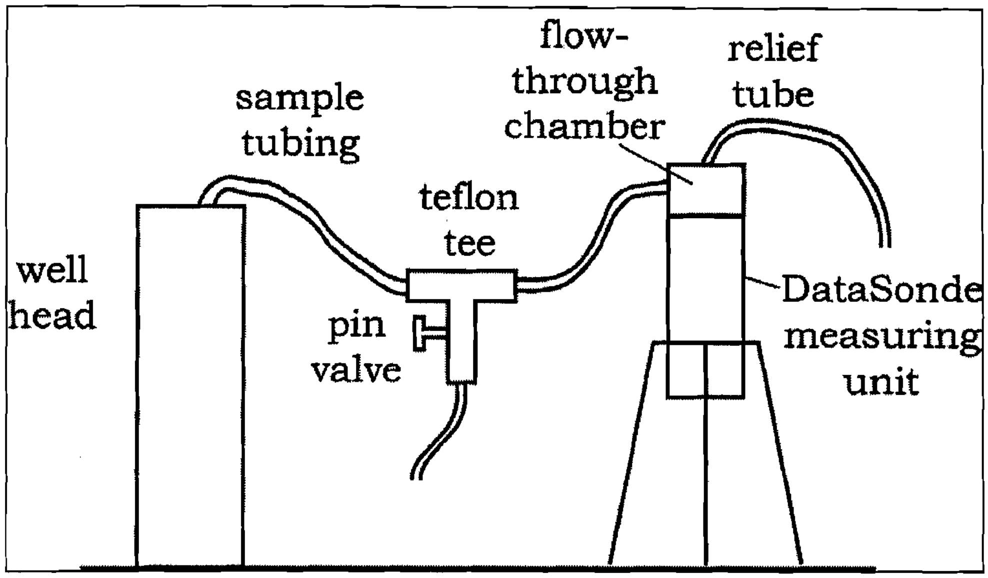

Figure 2. Cartoon of the sample setup used for the study

The bladder pumps are dedicated for each well and were operated using compressed nitrogen and a pressure control box to regulate the purge rate. The individual meters used for collecting the manual field parameters were the Beckman Φ210 pH meter with temperature probe, the Hach SensIon5 electrical conductance meter, and the Hach 2100P tubidimeter. The Hydrolab and the manual probes were calibrated and stored according to the manufacturers' recommendations.

Before the sampling event could begin, we made sure the sample setup was correct and the data logger was connected and programmed with the correct time, date and collection interval. We prepared the individual probes for use and ensured the sampling setup, instruments, and coolers were shaded.

Sampling Procedure

Sampling for this study began in April 2002 and ended in June 2002. The sampling procedure for the study follows the Laboratory's groundwater sampling protocol found in the Risk Reduction and Environmental Stewardship-Water Quality and Hydrology's (RRES-WQH) Groundwater and Surface Water Standard Operating Procedure, with the variation of sampling after the different purge volumes. A summary of the procedure is as follows.

First, a water level reading was taken to determine the height of water column in the well bore. To determine volume to be purged, a conversion factor for the diameter of the well pipe was multiplied by the height of the water column. The result, in gallons of water, was then converted to liters of water using the conversion factor: 1 gallon=3.78L.

Immediately after the pump was turned on, the drawdown was measured and the purge rate determined by timing the filling of a 1-liter container. At that point I estimated the length of time necessary to purge the well and collect each sample (Table 3). As the major cations and anions were filtered with a 0.45-micron filter attached directly to the sampling tubing during sampling, the flow rate was decreased for those samples. This process made it necessary to use volume in addition to time in determining when each purge volume was reached. For each well, pumping started at an initial setting of D and D (the middle settings on the control box for internal pressure and vent time), giving a purge rate of approximately 0.33 LPM, and adjusted as necessary. We used the first liter of water that was collected to determine the initial set of field parameter readings for the well.

Table 3. List of purge rates, purge volumes, and purge times for wells sampled.

Well	Purge rate (LPM)	Height of water (ft)	Multiplier to convert feet of water into gallons	Volume to purge (L)[2,3]	Time to purge (Min)[3,4]
CDBO-6	0.33, 0.24, 0.17[1]	11.19	0.163	6.89	40
LAO-C	0.74	9.85	0.367	13.66	10
LAO-0.7	0.33	11.62	0.163	7.16	22
LAO-3A	0.33	5.45	0.163	3.36	10
MCO-5	0.33	18.35	0.367	25.45	77
MCO-6	0.24	6.54	0.653	16.14	67
MCO-7	0.19	10.34	0.367	14.34	75

1. Purge rate used to determine purge time
2. 1 gallon =3.78 liters
3. Reflects one well bore
4. This is a minimum time; it does not take into account extra time for the filter being placed directly on the sample tubing.

Water for manual field parameter readings was collected through the sample port into 50 ml plastic cups, ideally every five minutes (or as close to that as possible). For the automated measurement done by the Hydrolab, water would continuously flow into the flow-through cell. Water level was collected every five minutes.

During the sampling event, water was continuously moving into the flow through-chamber of the Hydrolab. However, when the sample port was opened, water going into the flow-through cell was decreased. This process allowed air to travel back up the relief hose and into the flow-through chamber, affecting the DO and ORP measurements.

Water quality samples were collected after purging one-half, one, two, and three well bore volumes. The samples were later shipped to General Engineering Laboratories and analyzed.

Chemical Constituents, Sample Collection and Preparation

The chemical constituents were chosen because they represent a range of chemical behavior and may show variation during purging. For example, nitrate (NO_3^-) may be affected by biological activity and volatilization, which can change its concentration. Chloride (Cl^-) is one of the major anions, and is not affected by most chemical reactions.

Concentrations of Mn and Fe are sensitive to redox conditions, which affects their mobility and solubility. The concentrations of many metals may also vary with turbidity because the metals will tend to be sorbed to the particles that are floating in the water. If turbidity is high, and a sample is collected, the results may not be representative of the formation water. Na, Ca, Mg, and K are indicators of possible cation exchange effects and general water quality. Molybdenum has been found in high concentrations within Los Alamos Canyon (ESP, 2001) and is also conservative in nature.

Samples were collected in appropriate size containers and preserved if needed (Table 4).

Table 4. List of sample preparation and volumes

Category	Volume	Filtered/Unfiltered	Preservative	Analytes
Major Anions	250 ml	Filtered	H_2SO_4	NO_3, PO_4
Major Cations	1.0 L	Filtered	HNO_3	Ca, K, Mg, Na, Hardness
Major Anions	1.0 L	Filtered	None	Cl, F, SiO_2, SO_4, $CaCO_3$, HCO_3, CO_3, TDS
Metals	1.0 L	Unfiltered	HNO_3	Ag, Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Tl, V, Zn

Results and Discussion

In this section I will discuss the reliability of the Hydrolab and the manual readings, and general trends observed during purging. After that I will discuss individual results for the wells. Those results will be broken down by canyon, and then by well, starting at the uppermost well and working downstream. The accompanying plots show parameter readings from both data collected manually and using the Hydrolab, where available. Following that will be the chemistry plots.

The chemistry plots show the percent change in concentration during purging relative to the final sample. These plots illustrate changes between samples in relation to when we currently sample. This way we can determine if significant changes occur during purging and whether collecting a sample earlier would affect results. However, in showing the data in this way sometimes the differences are exaggerated. This exaggeration could occur when concentrations are small, are near or below the detection limit. The chemistry values are given in the Appendix.

I will now discuss information from field parameters obtained manually and with the Hydrolab. DO, ORP, and temperature values probably are not representative of the formation water due to issues with the sampling setup. The main problem with the DO and ORP readings was that the system was not airtight. For four of the seven wells, DO values stabilized after one well bore and were generally around 100% oxygen saturation, which would mean the water in the well would be fully oxygenated; however, these readings may not be representative of the formation water because air entered the flow-through cell.

ORP values were stable throughout the sampling event for all wells. The USGS discourages measuring redox as a routine parameter because of technical problems with collecting it. The USGS recommends using tubing impermeable to oxygen, an airtight sampling system, and the ability to purge atmospheric oxygen from the tubing and flow channels (USGS, 1998). None of these criteria were met in our setup. In addition, there are significant technical issues with interpreting results. At best, these ORP values could be used to see general trends.

In general temperatures do not represent formation water because the water temperature changes when measured in an instrument that has been warmed by the sun, or when measured in a cup. Temperature values for the manual readings stabilized at four of the seven wells, based on NMED criteria. The other three wells either showed no stabilization, or showed only brief periods of stabilization. In general, Hydrolab temperature readings did not stabilize. Lack of stabilization is due to the same reasons mentioned above.

Other field parameter values (turbidity, pH, and EC) were more likely representative of the formation. Turbidity measurements with the Hydrolab did not work until we shielded the instrument from light, so MCO-5, MCO-6 and CDBO-6 do not have Hydrolab turbidity readings. Once the instrument was covered, Hydrolab readings could be collected. Hydrolab turbidity readings were stable at only one location, which was LAO-0.7, and were close to the manual readings at only two locations, LAO-0.7 and MCO-7. The manual readings were self-consistent and generally below 5 NTU. At MCO-7 and CDBO-6 turbidity was up to 25 NTU or more. The pH and EC values for both the Hydrolab and the manual readings stabilized after one-half well bore purged and are in agreement with each other. Drawdown for all of the wells stabilized by the second well bore purged. In some cases, stabilization was seen as early as one-half well bore purged. In four of the seven wells drawdown was more than NMED's recommended 0.3 ft.

In general, the metal concentrations changed little while sampling a well, with the largest decrease seen in Al and Fe between one-half and one well bore purged. This trend corresponds to the turbidity trend for five of the seven wells. The major cation and major anion constituents showed little change during purging. These constituents were filtered before sampling.

There are two important observations relating purge volume and water quality. The first observation relates to drawdown, and how drawdown affects turbidity. In this study we found that greater drawdown (> 0.8 ft), increased turbidity (>20 NTU). Table 5 summarizes water level, drawdown, purge rate, and initial and final turbidity readings for both manual collection and from the Hydrolab (where available). Figure 3 shows the overall relationship between drawdown and stabilized turbidity. The second observation is that turbidity trends correspond to trends in the concentration of Al and Fe. This will be discussed in more detail for each well.

Table 5. Overview of the wells sampled and the range of results for drawdown and turbidity.

Well	Date	Initial water level (ft)	Initial draw-down (ft)	Stabilized drawdown (ft)	Purge rate (LPM)	Initial manual turbidity[1]	Final manual turbidity	Manual turbidity collected by	Initial Hydrolab turbidity range	Final Hydrolab turbidity range
LAO-C	4/23/02	4.4	0 to 0.5	0.1	0.54, 0.31	9.28	3.8	WQH	NA	NA
LAO-C	6/4/02	4.6	0 to 0.15	0.15	0.74	4.27	2.4	WGI	7.8 to 5.2	4.1 to 3.2
LAO-0.7	4/24/02	16.1	0 to 0.20	0.15	0.25	10.9	2.6	WQH	NA	NA
LAO-0.7	6/4/02	14.38	0 to 0.52	0.6	0.33	6	0.57	WGI	16.5 to 8.7	7.4 to 5.5
LAO-3A	4/25/02	9.68	0	0.08	0.24, 0.33	6.13	2.5	WQH	NA	NA
LAO-3A	6/4/02	10.06	0	0.03	0.33	3.15	2.3	WGI	NA	Erratic
MCO-5	5/30/02	29.6	0 to 0.81	0.6	0.33	1.76	0.75	WQH	NA	NA
MCO-6	5/29/02	42.8	0 to .24	0.24	0.24	3.26	0.7	WQH	NA	NA
MCO-7	6/5/02	46.4	0 to 0.89	0.9	0.19	10	22	WQH	9.6 to 27.1	27.1 to 6.3
CDBO-6	5/31/02	39.31	0.48-1.38	1.38	0.33, 0.24, 0.17	95	35	WQH	NA	NA

1. NMED's Hazardous Waste Bureau recommends achieving turbidity readings of < 5 NTU prior to sampling. This is an ideal number and may vary depending on site conditions.

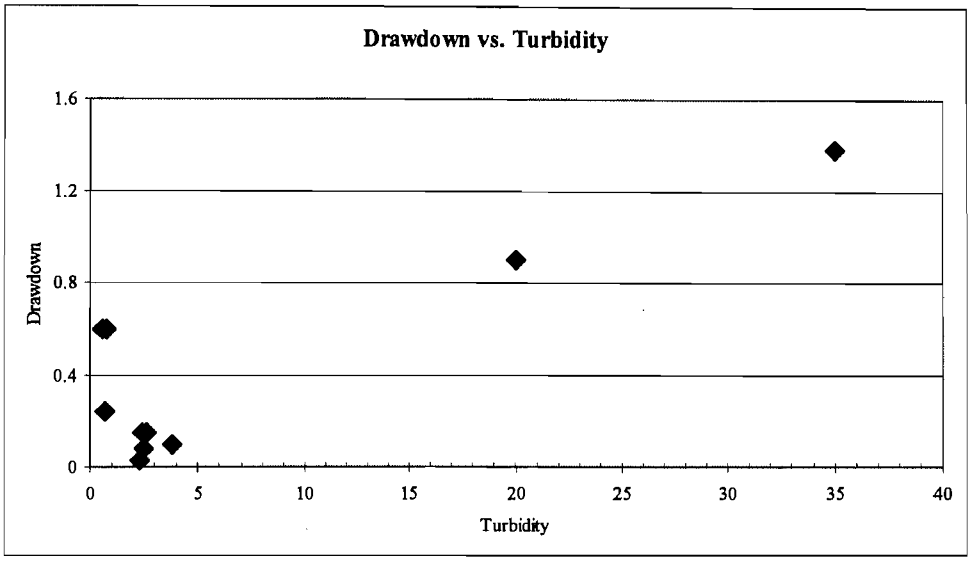

Figure 3. Drawdown vs. stabilized manual turbidity. Drawdown in excess of 0.8 ft increases turbidity significantly.

Los Alamos Canyon

LAO-C

I collected data at LAO-C on 4/23/02 and 6/04/02. We collected field parameters and chemistry on both dates, but Hydrolab data only on 6/04/02.

On 4/23/02 the drawdown for LAO-C stabilized after one well bore, while on 6/04/02 drawdown stabilized after two well bores of water purged (Figures 4 and 5). The overall decline for both dates was approximately 0.15 ft at a purge rate of 0.31 LPM on 4/23/02, and 0.74 LPM on 6/04/02. The main difference to point out here is that the purge rate was higher on 6/04/02 with a drawdown approximately the same as the event on 4/23/02, which was purged at about half the rate. Upon looking at this issue, I found that for both events the water level was virtually the same, the amount of water to purge was nearly the same, and the collection times for both events were very close to the same. This indicates I made a note taking error when writing down the purge rate on 6/04/02.

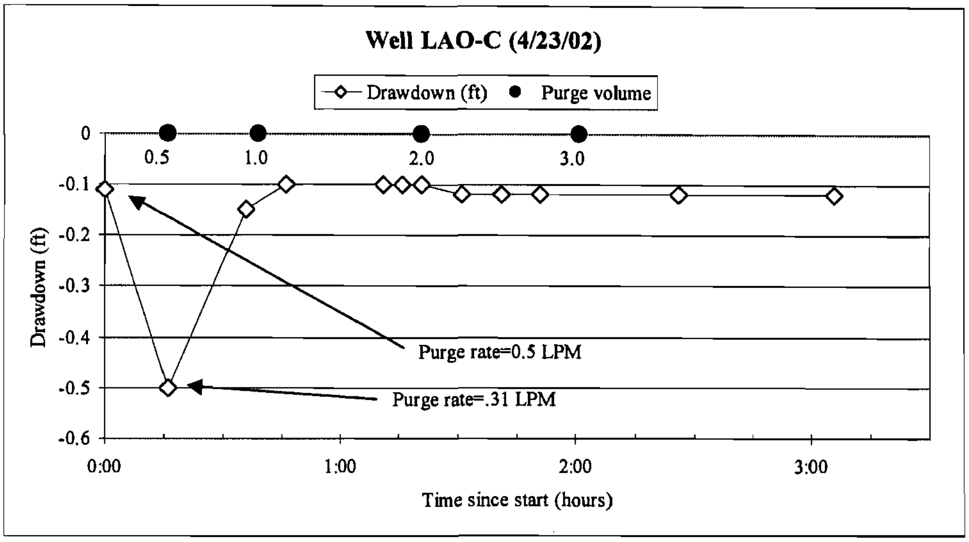

Figure 4. Well LAO-C (4/23/02) drawdown. Solid circles indicate the number of well bores purged.

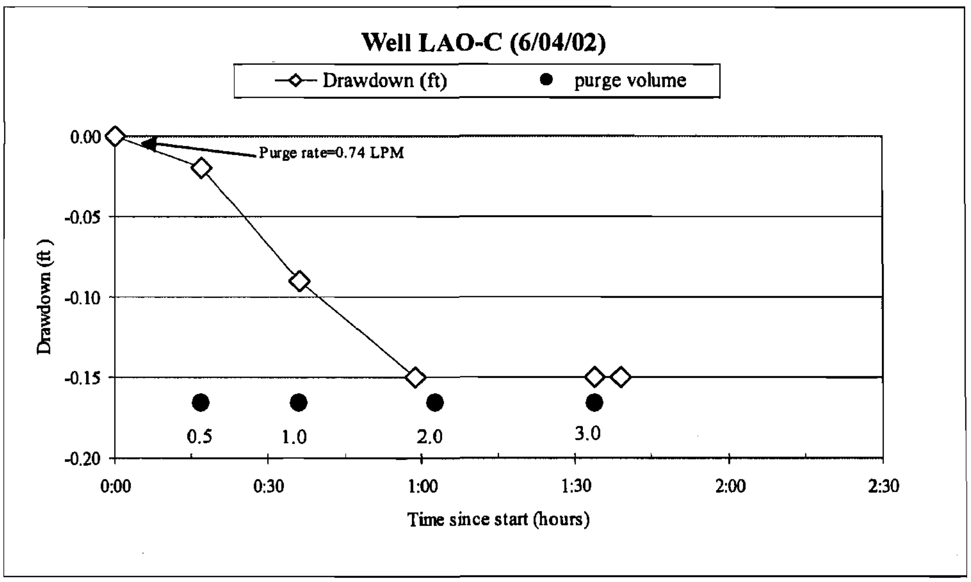

Figure 5. Well LAO-C (6/04/02) drawdown. Solid circles indicate the number of well bores purged.

The manual readings for turbidity on both sampling dates (Figure 6 and 7) stabilized after one well bore purged. Hydrolab readings were higher, more scattered, and did not stabilize (Figure 7). Note turbidity on 4/23/02 went from 9 to 4 NTU and on 6/04/02 went from 4 to 2 NTU. One reason for the difference is because the readings were taken with different turbidity meters. Another reason could have been from calibration differences.

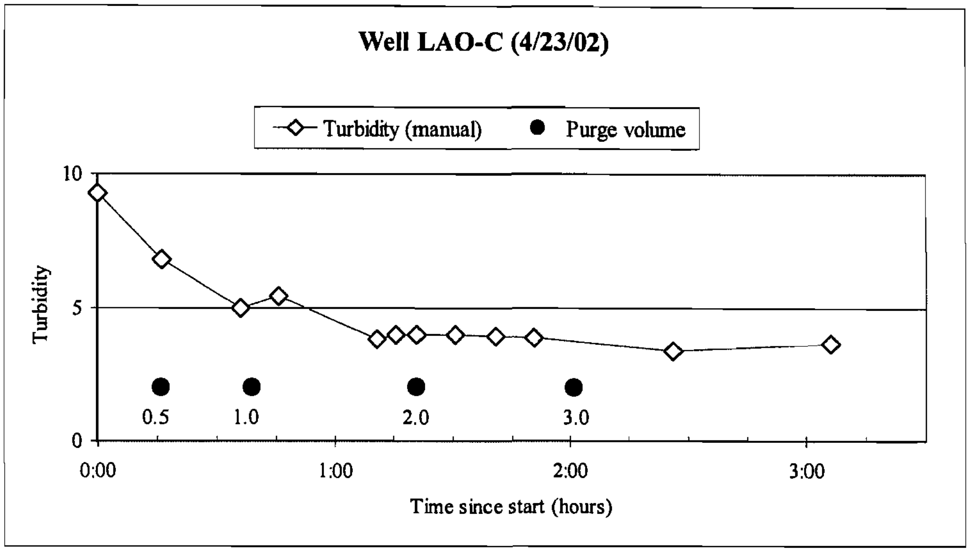

Figure 6. Well LAO-C (4/23/02) turbidity results from manual readings. Solid circles indicate the number of well bores purged.

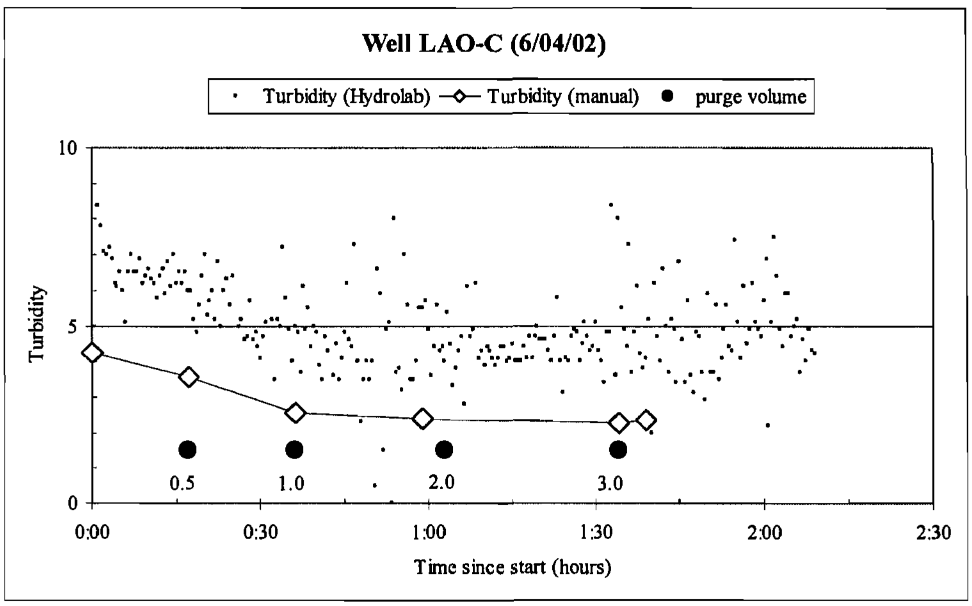

Figure 7. Figure 6. Well LAO-C (6/04/02) turbidity results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

The manual readings for pH on both dates stabilized after one-half well bore (Figures 8 and 9). Hydrolab readings for pH stabilized after one-half well bore purged (Figure 9). The Hydrolab values were slightly lower than the manual values. This may be due to calibration differences of the probes.

For EC, the results for both events were stable throughout the event. On 4/23/02 EC stabilized at around 450 μS/cm, on 6/04/02 EC stabilized at approximately 500 μS/cm (Figures 10 and 11). These differences may be attributed the fact that different instruments were used for each event, or the differences could be due to calibration differences. EC from the Hydrolab were stable throughout the event at approximately 505 μS/cm (Figures 11).

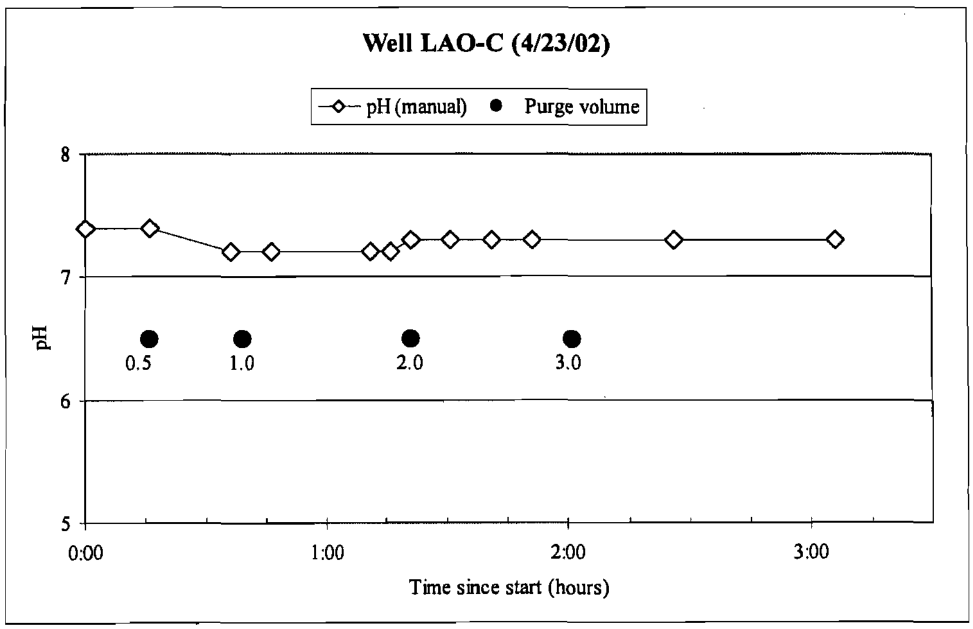

Figure 8. Well LAO-C (4/23/02) pH results from manual readings. Solid circles indicate the number of well bores purged.

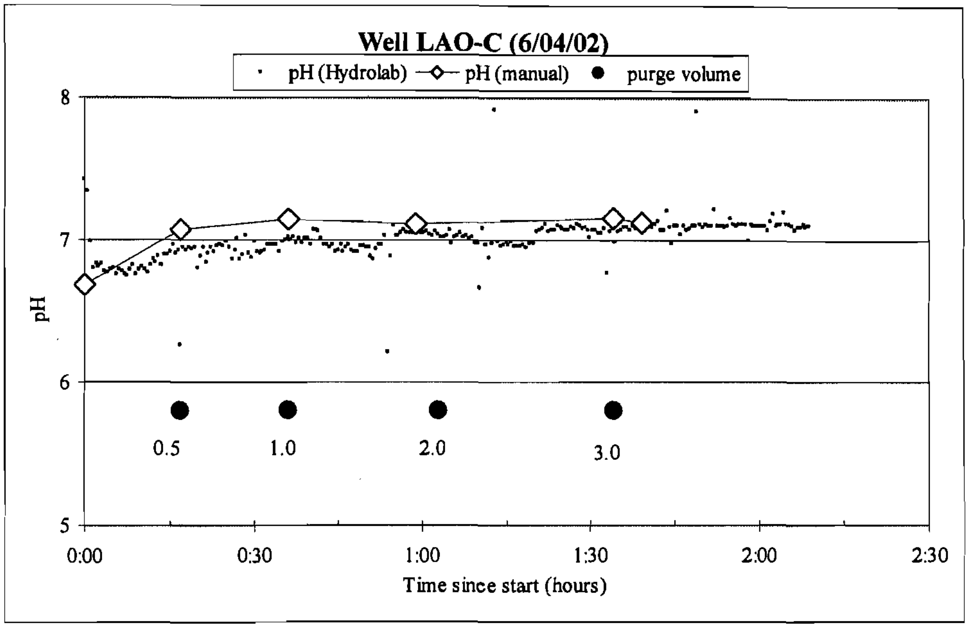

Figure 9. Well LAO-C (6/04/02) pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

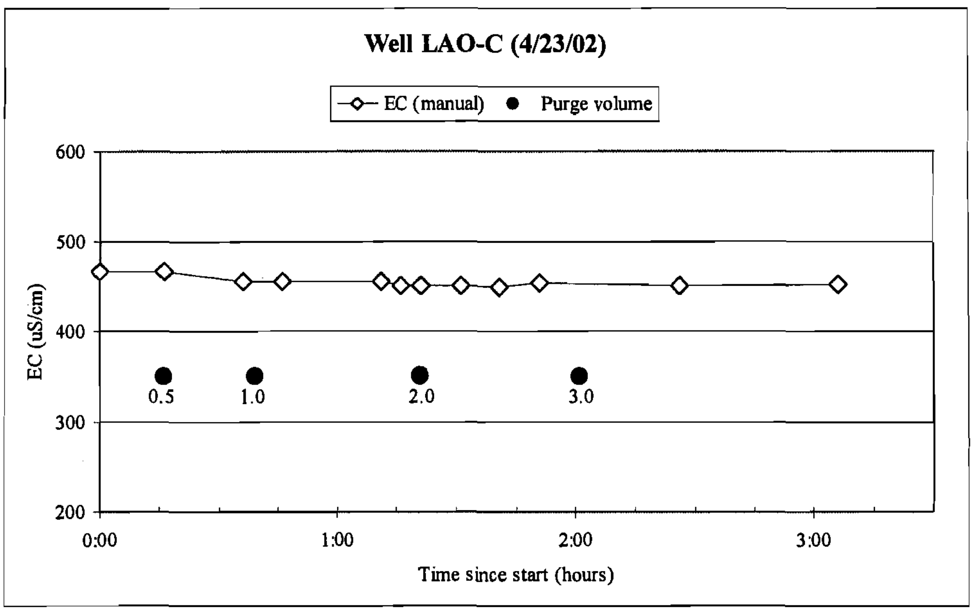

Figure 10. Well LAO-C (4/23/02) conductance results from manual readings. Solid circles indicate the number of well bores purged.

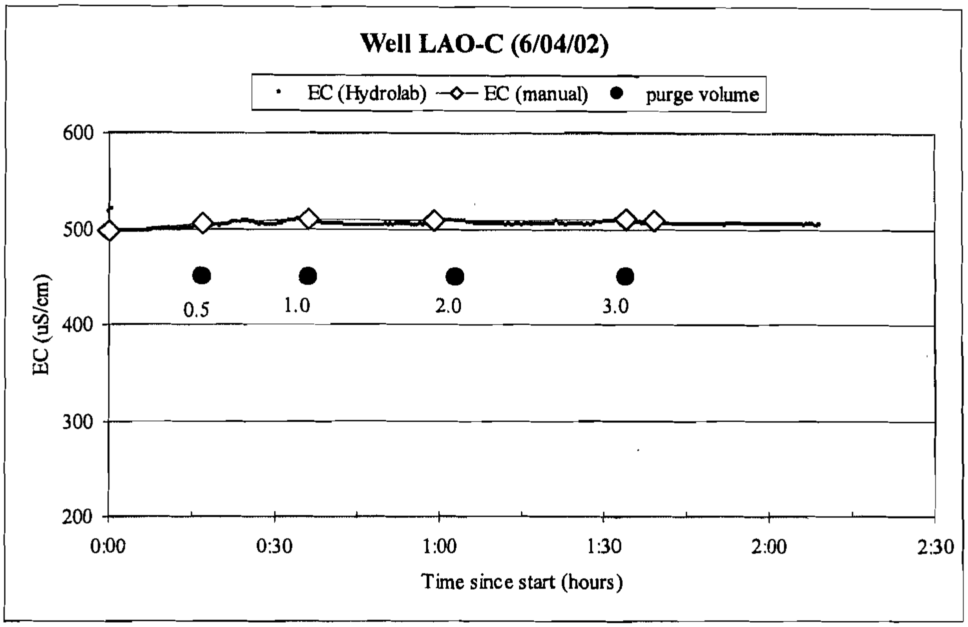

Figure 11. Well LAO-C (6/04/02) conductance results from Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

Temperature gradually increased throughout both sampling events, although based on NMED criteria, both the manual readings and the Hydrolab readings show stabilization throughout purging (Figures 12 and 13). The temperature results are not representative of the formation water as discussed earlier.

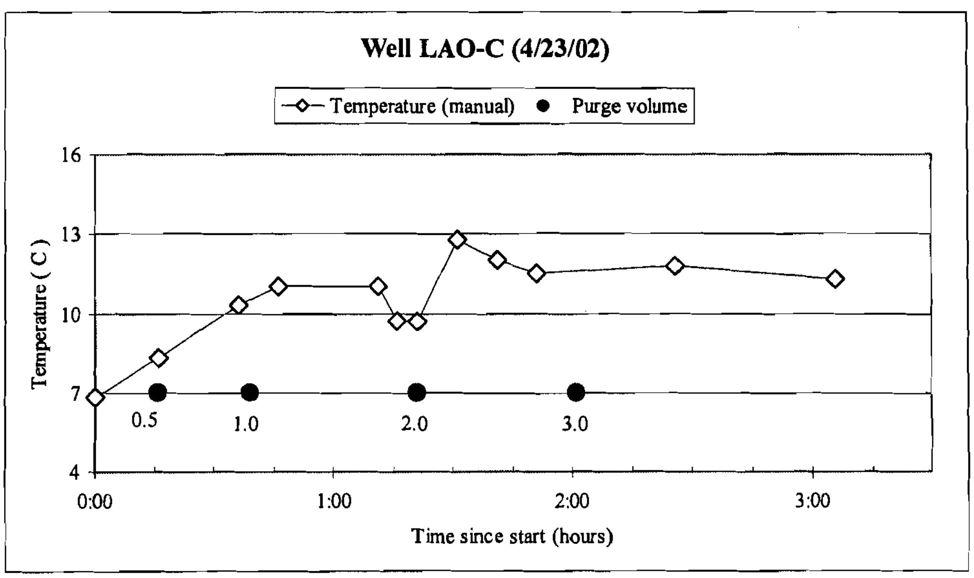

Figure 12. Well LAO-C (4/23/02) temperature results from manual readings. Solid circles indicate the number of well bores purged.

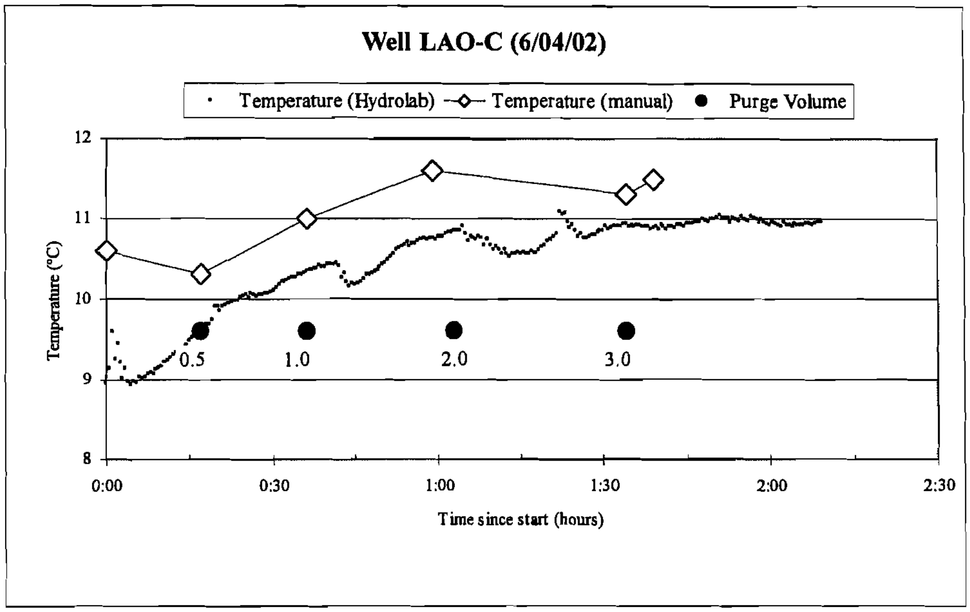

Figure 13. Well LAO-C (6/04/02) temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

LAO-C was one of the wells where DO readings did not stabilize (Figure 14). The cyclic nature of the DO readings for the first 1.5 hours is suspect. Possible explanations for this could be that the DO probe on the Hydrolab was not working properly, the instrument was out of calibration, or oxygen was entering the flow-through cell during sampling. LAO-0.7, which was sampled on the same day, exhibits cyclic DO readings similar to LAO-C. In contrast, LAO-3A, which was sampled the following day, did not show this cycling of DO. The ORP readings were stable after one-half well bore at around 320 mV (Figure 15).

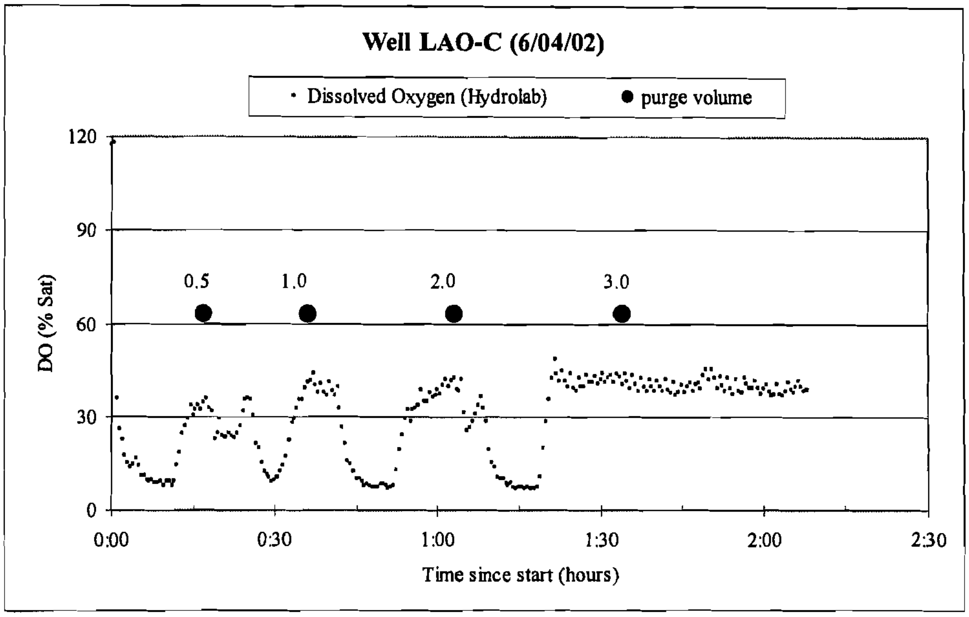

Figure 14. Well LAO-C (6/04/02) dissolved oxygen results from the Hydrolab. Solid circles indicate the number of well bores purged.

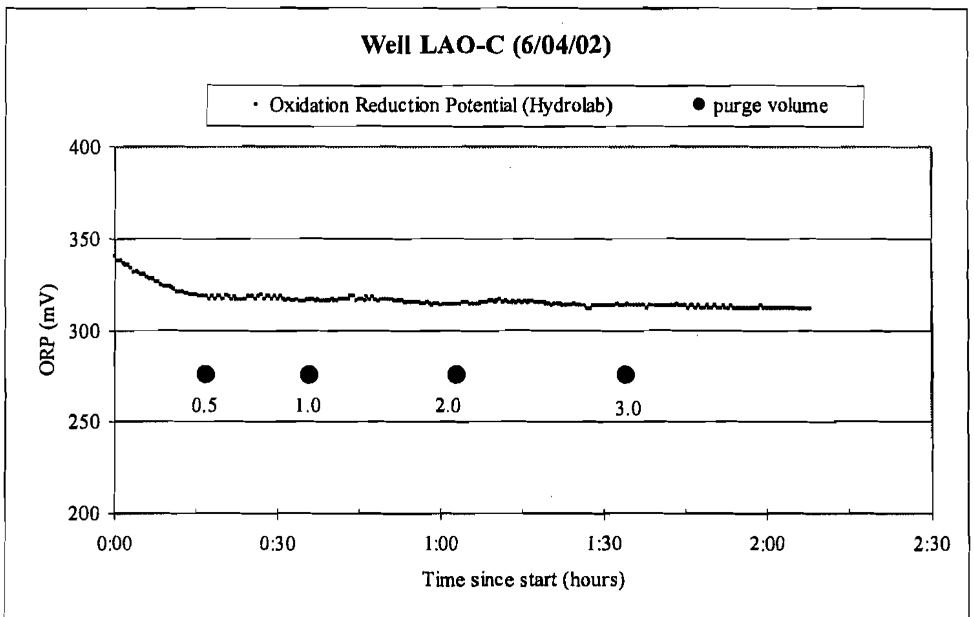

Figure 15. Well LAO-C (6/04/02) oxidation-reduction potential results from the Hydrolab. Solid circles indicate the number of well bores purged.

The chemistry analysis for the samples collected on 4/23/02 showed that Al, Fe, and Mn decreased from one-half to three well bores, with Mn showing the largest decrease from one-half to one well bore (Figure 16). For the samples taken on 6/04/02, LAO-C showed that Al and Fe decreased notably from one-half well bore to one well bore purged, and changed less from one well bore to three well bores purged (Figure 17). For the samples collected on 6/04/02, Mn and Cr show a similar trend to the Al and Fe trend seen from the same event, with a substantial drop from one-half to one well bore purged (Figure 18). After one well bore purged, their concentrations drop below the detection limit. Al, Fe, Mn, and Cr, and turbidity all decrease up to one well bore purged, and then level off, similar to turbidity. This result suggests that turbidity has a large effect on sample quality. The most striking difference between the two dates is the change in percent difference. For example, on 4/23/02 Al and Fe change as much as 800% from the final sample, where as on 6/04/02, Al and Fe change by 120% and 50%(respectively) from the final sample.

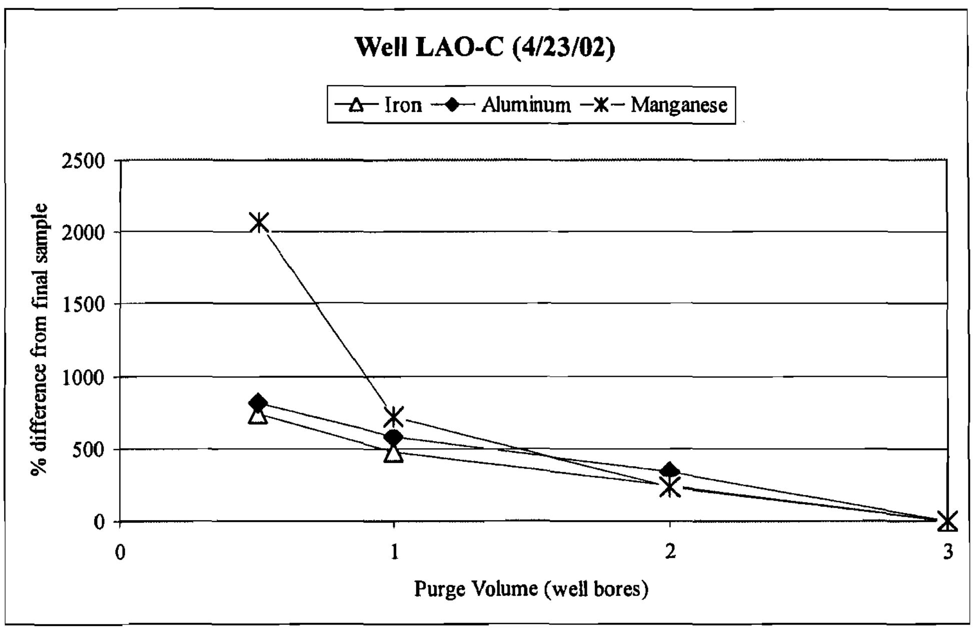

Figure 16. Well LAO-C (4/23/02) Al, Fe, and Mn results compared to the final sample.

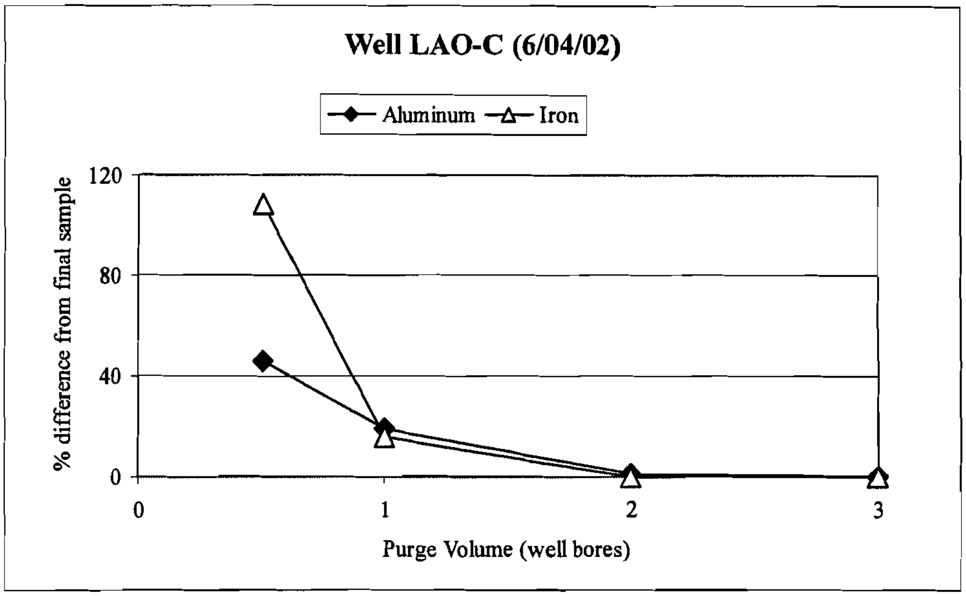

Figure 17. Well LAO-C (6/04/02) Al and Fe results compared to the final sample.

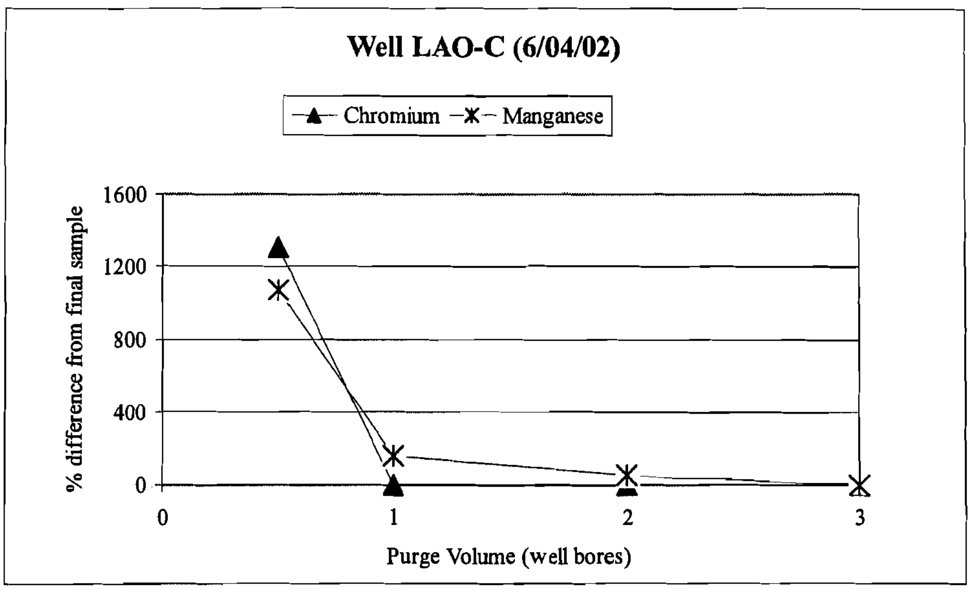

Figure 18. Well LAO-C (6/04/02) Cr and Mn results compared to the final sample. In this case, Cr drops below the detection limit from one well bore to three well bores. Mn dropped below the detection limit from two to three well bores purged.

For both sampling events, Ba and Sr show little change throughout the event (Figures 19 and 20). For example, Ba concentrations on 4/23/02 were 76.6 µg/L, 72.3 µg/L, 71.3 µg/L, and 70.6 µg/L. For the samples collected on 6/04/02 the concentrations were 85.2 µg/L, 83.6 µg/L, 83.2 µg/L, and 81.4 µg/L. For the sample collected on

4/23/02, the changes in Zn concentrations are slight up to the third sample, however they exaggerated on the graph (Figure 19). Concentrations of Zn at the third and fourth sample drop below the detection limit.

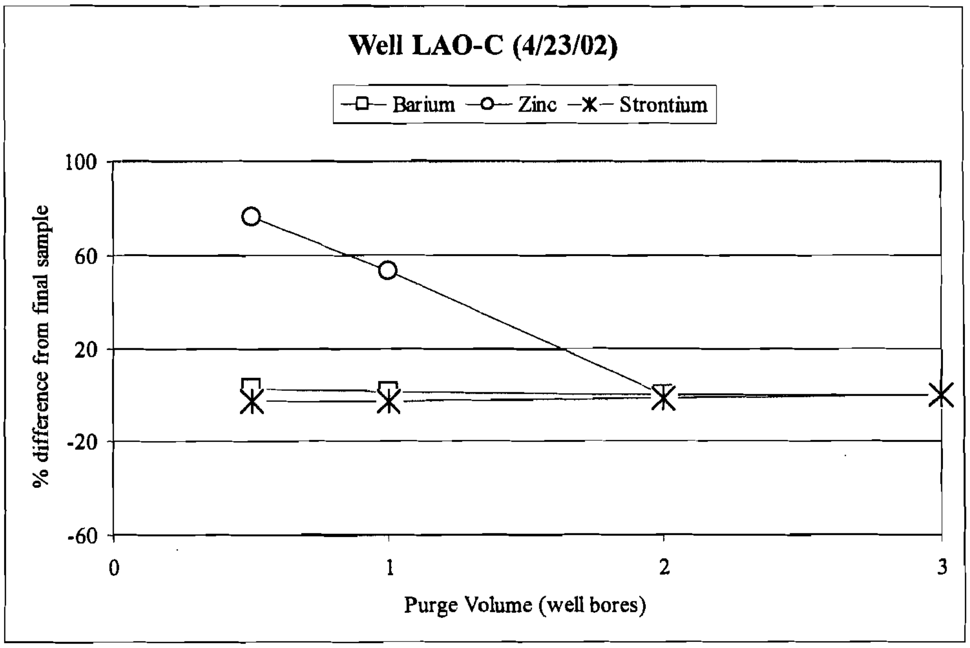

Figure 19. Well LAO-C (4/23/02) Ba, Zn and Sr results compared to the final sample. Concentrations changed little.

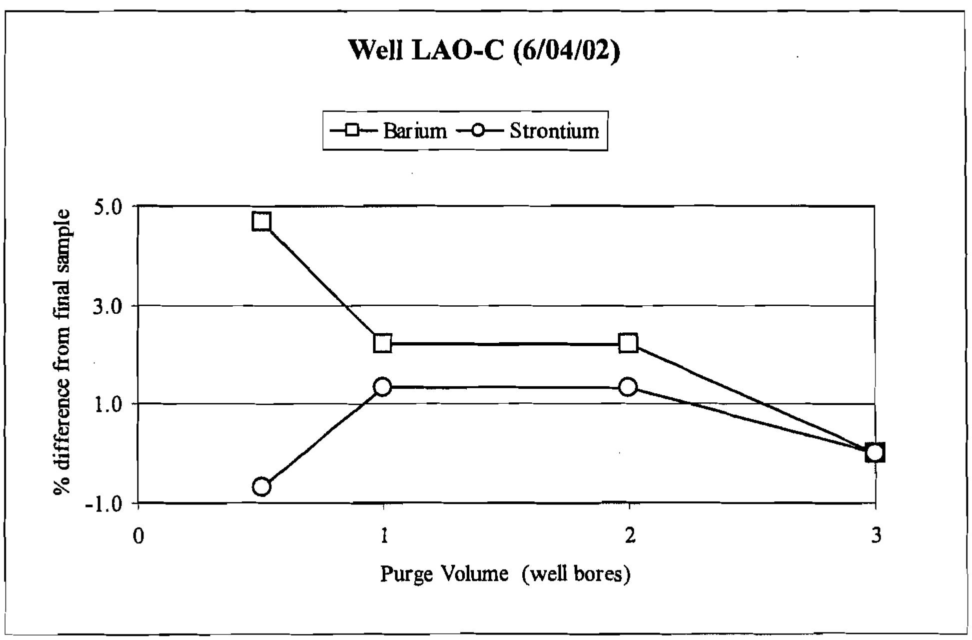

Figure 20. Well LAO-C (6/04/02) Ba and Sr results compared to the final sample. Concentrations changed little.

For both sampling events total phosphorous, total alkalinity, and fluoride concentrations change little after one-half well bore (Figures 21 and 22). For example, the concentrations of total phosphorous taken on 4/23/02 were 0.07 mg/L., 0.07 mg/L, 0.03 mg/L, and 0.04 mg/L. For the sample collected on 6/04/02 the concentrations were 0.03 mg/L, 0.04 mg/L, 0.04 mg/L, and 0.03 mg/L. These are close to the detection limit of 0.011 mg/L. Another example is fluoride. On 4/23/02 the concentrations were 0.096 mg/L, 0.153 mg/L, 0.155 mg/L, and 0.155 mg/L. For the event on 6/04/02 the concentrations were 0.168 mg/L, 0.179 mg/L, 0.21 mg/L, and 0.176 mg/L. For nitrate-nitrite as nitrogen for both sampling events, the graph depicts a large change between samples, but the concentrations are close to the detection limit of 0.01 mg/L. For both sampling events, the results for the remaining constituents, total dissolved solids, chloride and sulfate (Figures 23 and 24), and the major cation and anion constituents (Figures 25 and 26) show little change between the different well bore volumes purged.

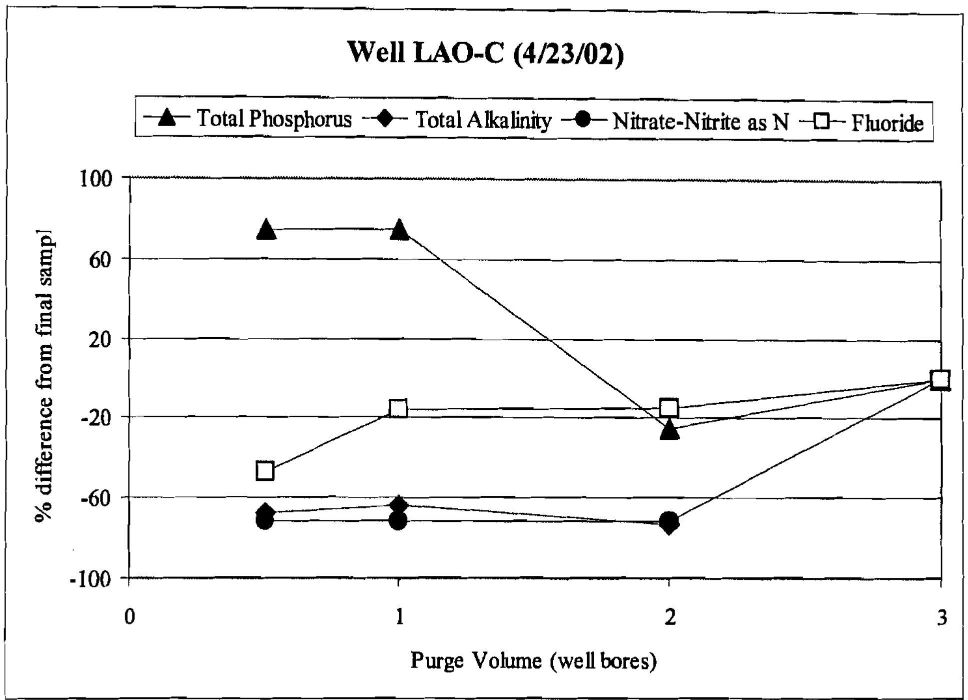

Figure 21. Well LAO-C (4/23/02) total phosphorous, total alkalinity, nitrate-nitrite as nitrogen, and fluoride results compared to the final sample.

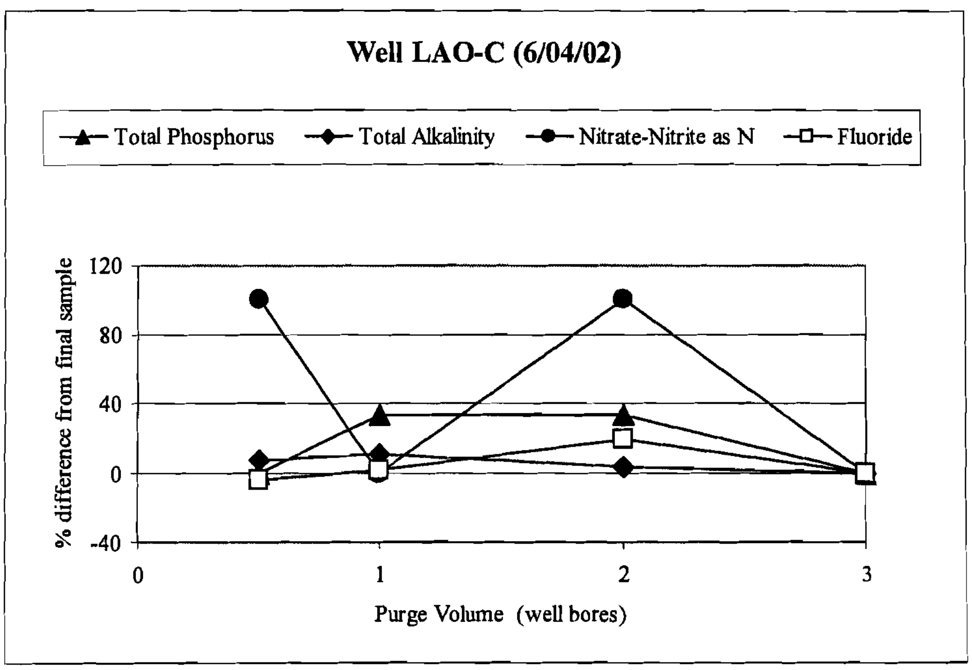

Figure 22. Well LAO-C (6/04/02) total phosphorous, total alkalinity, nitrate-nitrite as nitrogen, and fluoride results compared to the final sample.

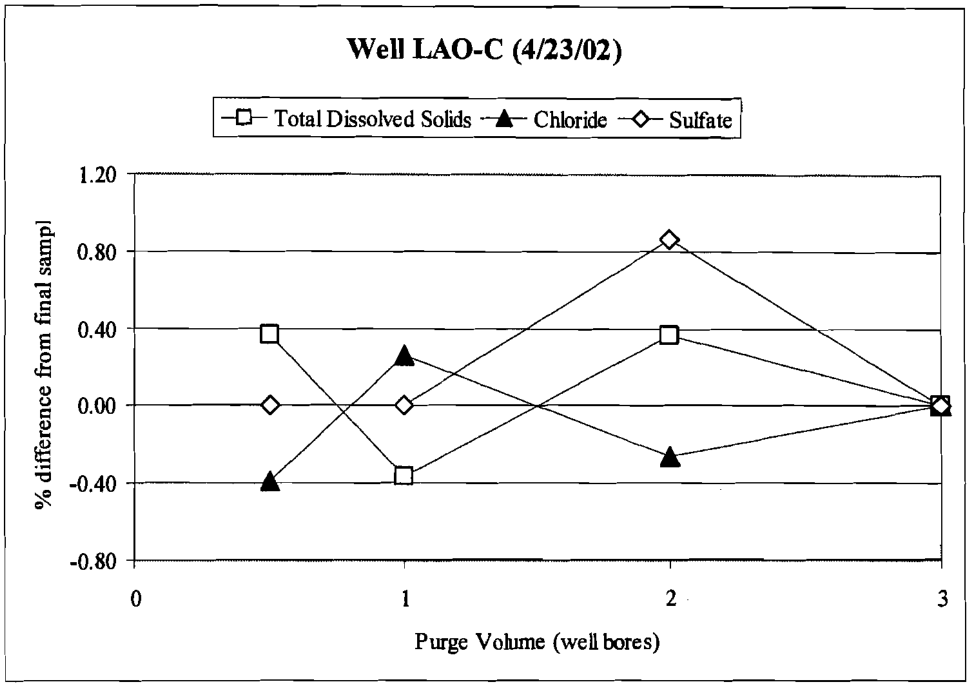

Figure 23. Well LAO-C (4/23/02) chloride, sulfate, and total dissolved solids results compared to the final sample. Concentrations changed little.

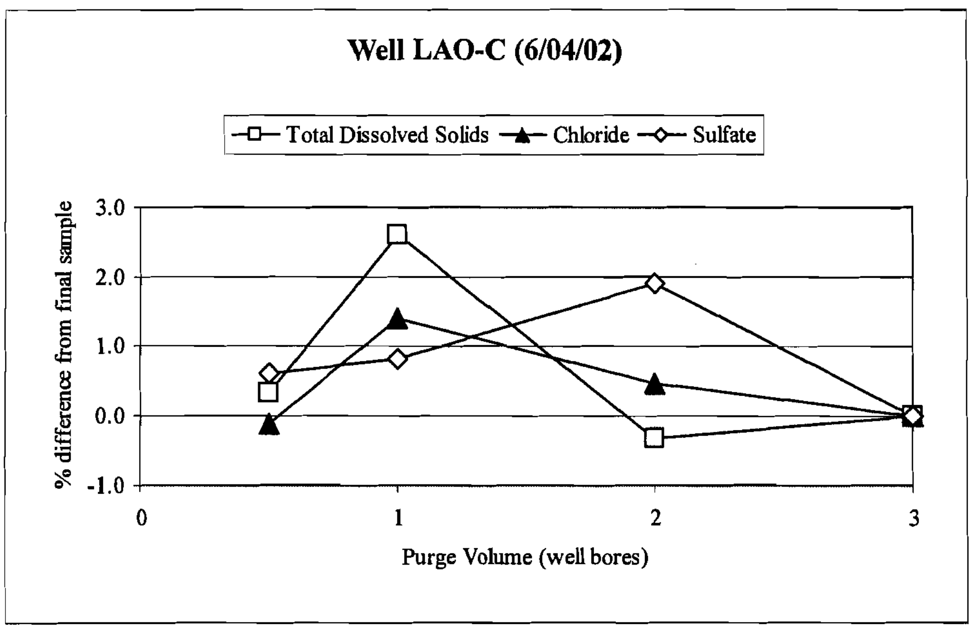

Figure 24. Well LAO-C (6/04/02) chloride, sulfate, and total dissolved solids results compared to the final sample. Concentrations changed little.

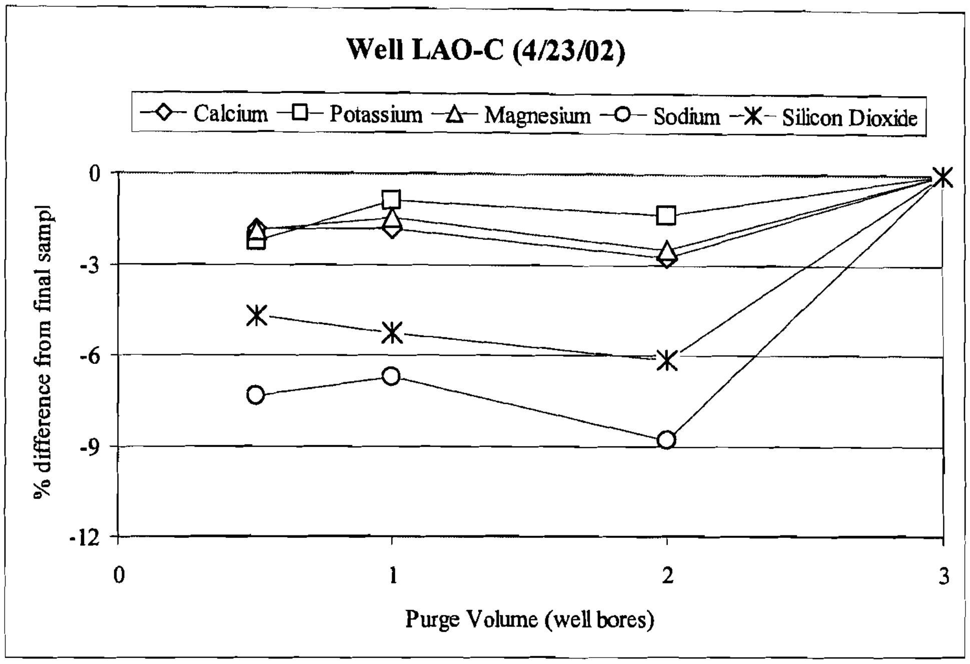

Figure 25. Well LAO-C (4/23/02) Ca, K, Mg, Na and SiO_2 results compared to the final sample. Concentrations changed little.

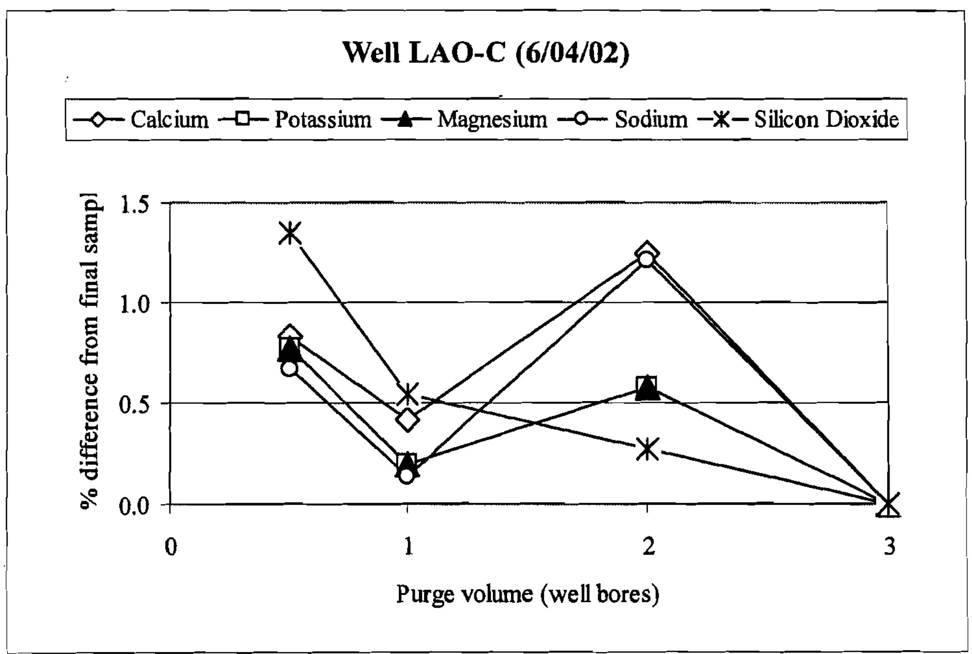

Figure 26. Well LAO-C (6/04/02) Ca, K, Mg, Na and SiO_2 results compared to the final sample. Concentrations changed little.

LAO-0.7

For LAO-0.7, drawdown stabilized by one-half well bore purged at approximately 0.5 ft at a purge rate of 0.33 LPM (Figure 27). This rate is lower than the 0.3 ft NMED recommends for drawdown on a well, although NMED state this may vary from well to well. Although the drawdown stabilized, I purged at too high a rate, increasing the drawdown, turbidity and sample aeration.

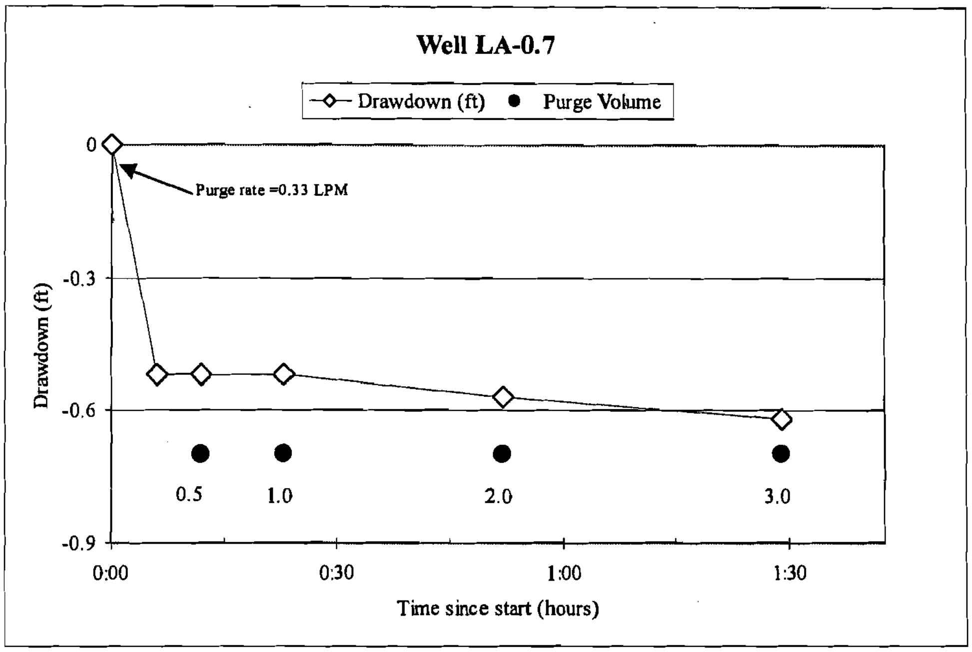

Figure 27. LAO-0.7 drawdown. Solid circles indicate the number of well bores purged.

The manual readings for turbidity (Figure 28) did not stabilize based on the NMED criteria, but the readings were around 4.0 NTU, which is higher than several of the other wells with less drawdown. Hydrolab readings were higher, and did not really stabilize. A possible reason for the difference in turbidity readings could be sensitivity of the turbidity probe on the Hydrolab to light or the purge rate was to high. There are too few data to support what happened.

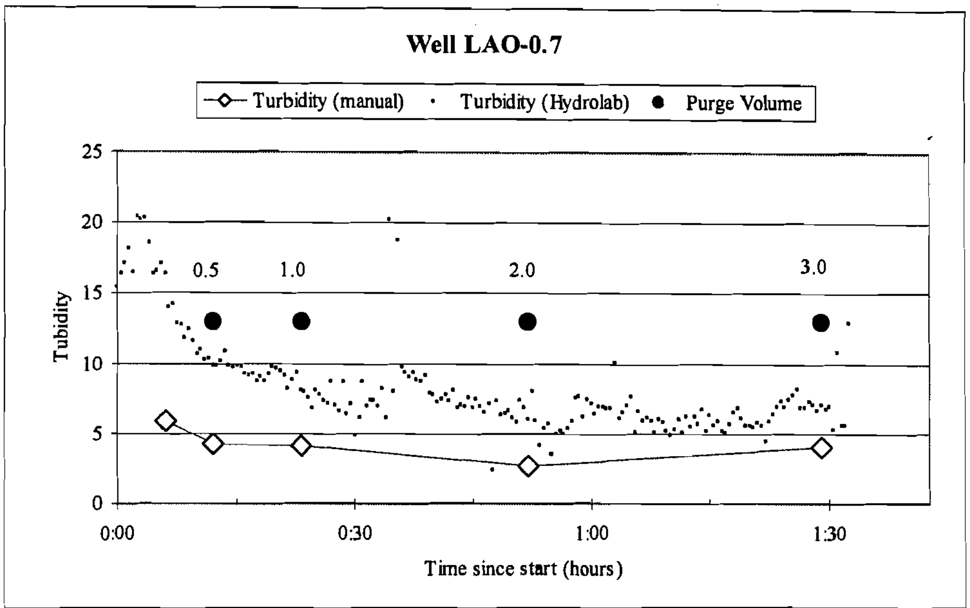

Figure 28. LAO-0.7 turbidity results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

Both the manual readings and the Hydrolab readings for pH and EC were stable throughout the sampling event (Figures 29 and 30). Manual readings for pH stabilized around 6.8, while Hydrolab pH values were slightly lower than the manual values at around 6.4, which may be due to calibration differences of the probes. EC readings for both stabilized at approximately 410μS/cm.

Temperature for LAO-0.7 gradually decreased throughout the sampling event, although the Hydrolab showed some stabilization after 1.5 well bores purged. The manual readings did not stabilize (Figure 31). LAO-0.7 was the second well where the DO readings did not stabilize (Figure 32). The ORP readings showed stabilization throughout the event at around 348 mV (Figure 33).

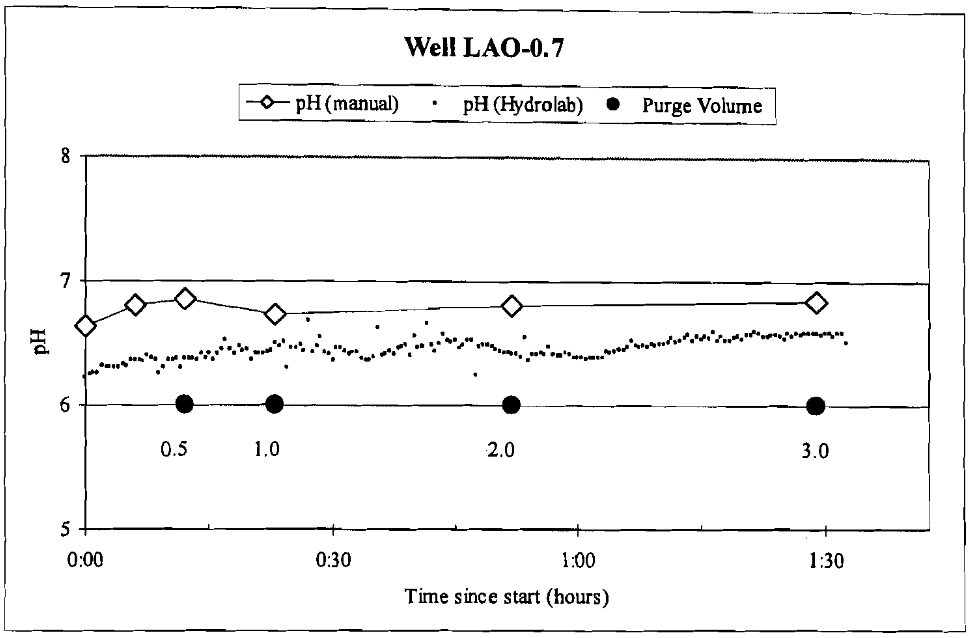

Figure 29. LAO-0.7 pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

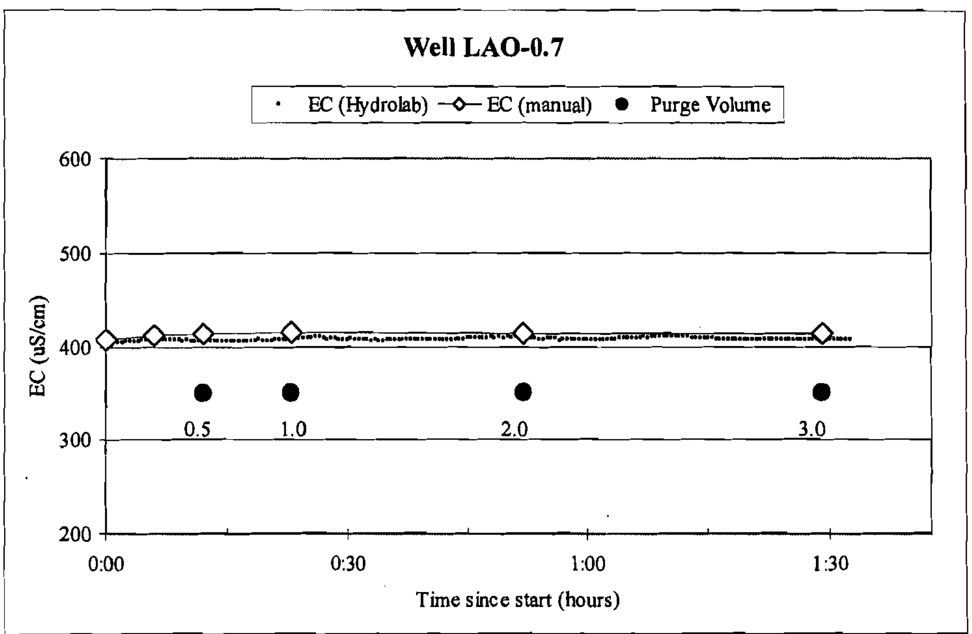

Figure 30. LAO-0.7 conductance results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

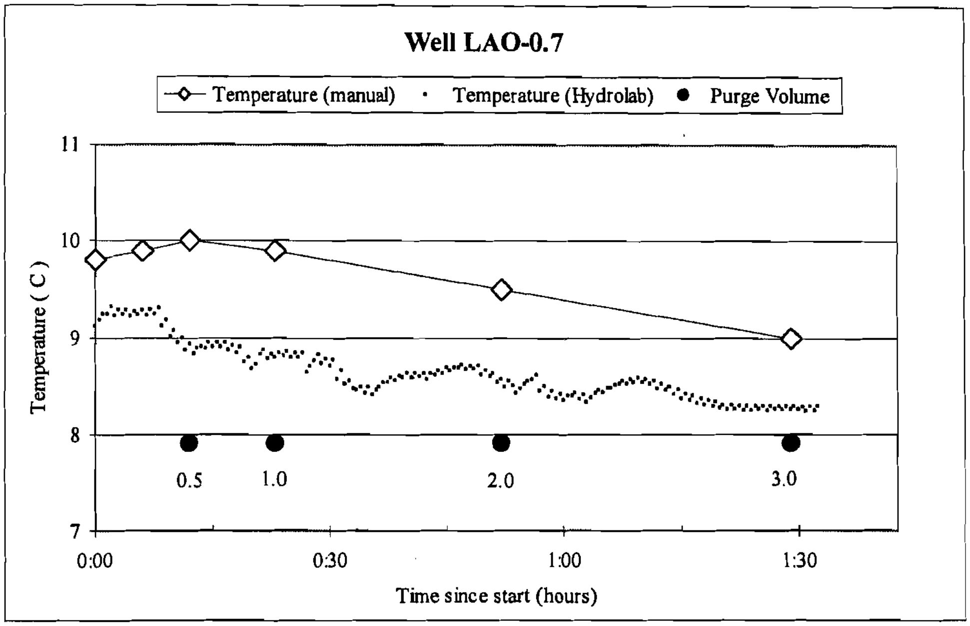

Figure 31. LAO-0.7 temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

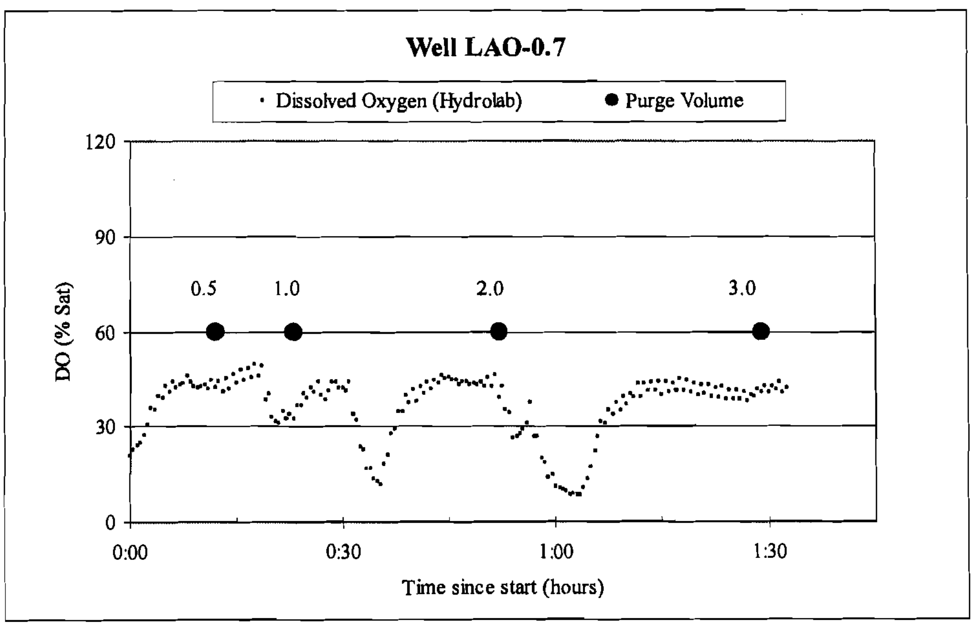

Figure 32. LAO-0.7 dissolved oxygen results from the Hydrolab. Solid circles indicate the number of well bores purged.

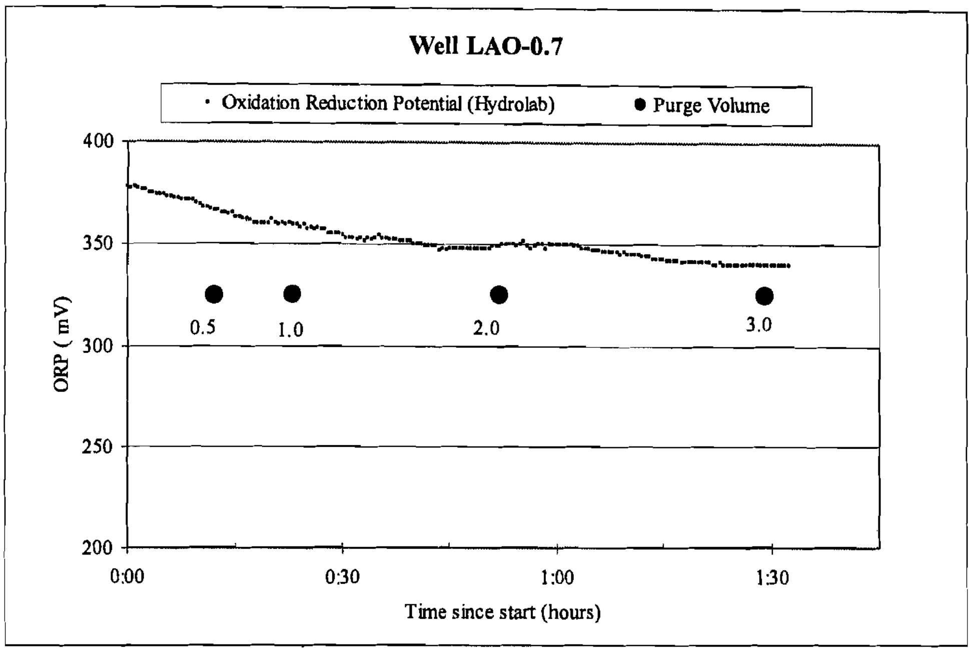

Figure 33. LAO-0.7 oxidation-reduction potential results from the Hydrolab. Solid circles indicate the number of well bores purged.

The chemistry for LAO-0.7 showed that Al, Fe and Mn all decreased from one-half to two well bores purged, with little subsequent change, similar to turbidity (Figure 34). The other metal showing changes is Cd (Figure 34), although the concentration values are near the detection limit. Ba and Sr change little after one-half well bore purged (Figure 35).

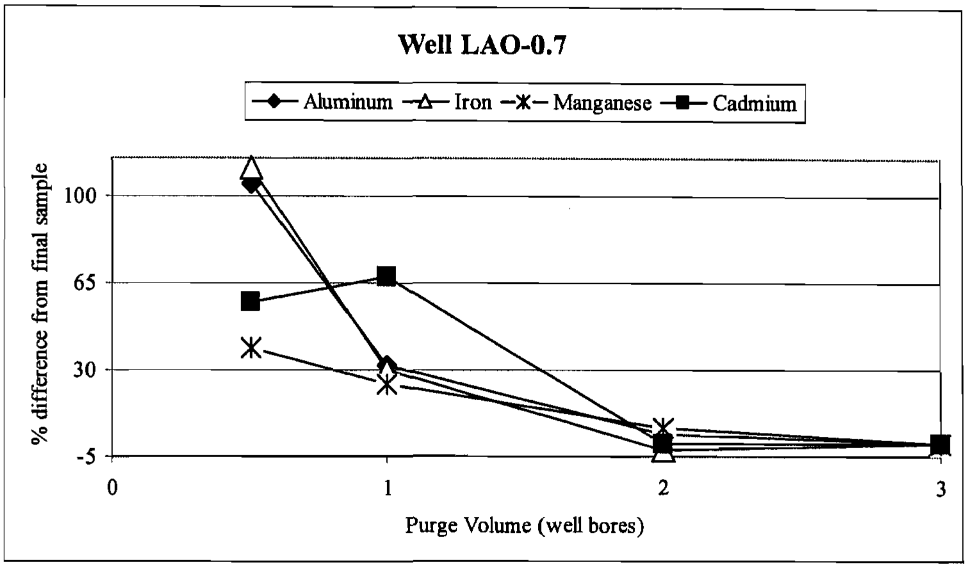

Figure 34. LAO-0.7 Al, Fe, Mn, and Cd results compared to the final sample. Cd concentrations were near the detection limit.

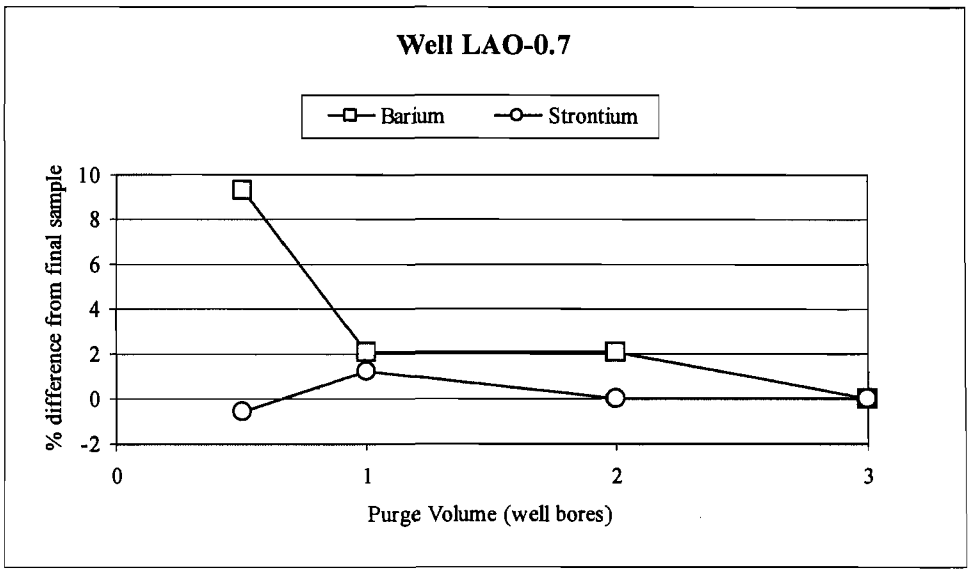

Figure 35. LAO-0.7 Ba and Sr results compared to the final sample.

For chloride, and sulfate there was little change. Nitrate-nitrite as nitrogen and fluoride show large changes from one-half to three well bores purged, although changes in concentrations are slight (Figure 36). For example, the concentrations for nitrate-nitrite as nitrogen were 0.73 mg/L, 0.66 mg/L, 0.63 mg/L, and 0.63 mg/L, while the concentrations for fluoride were 0.207 mg/L, 0.231 mg/L, 0.202 mg/L, and 0.181 mg/L.

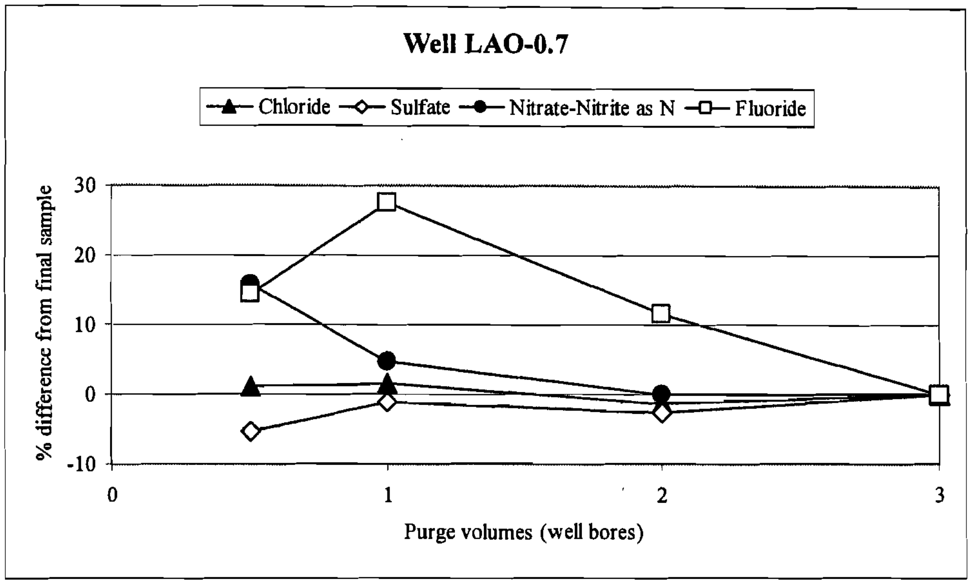

Figure 36. LAO-0.7 chloride, sulfate, nitrate-nitrite as nitrogen, and fluoride results compared to the final sample. Concentrations changed little.

Total dissolved solids and total alkalinity concentrations changed only slightly after one-half well bore purged, while total phosphorous was near the detection limit of 0.01 mg/l (Figure 37). Results for the remaining major cations and anions showed little change between the different samples after one-half well bore was purged (Figure 38).

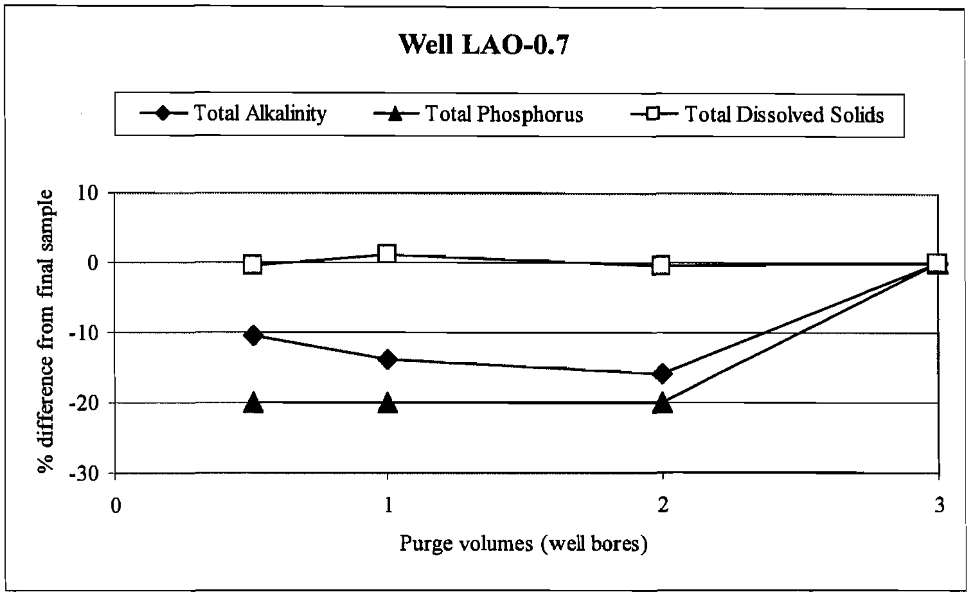

Figure 37. LAO-0.7 total phosphorous, total alkalinity, and total dissolved solids results compared to the final sample. Total alkalinity and total dissolved solid concentrations changed little, while total phosphorous concentrations were near the detection limit.

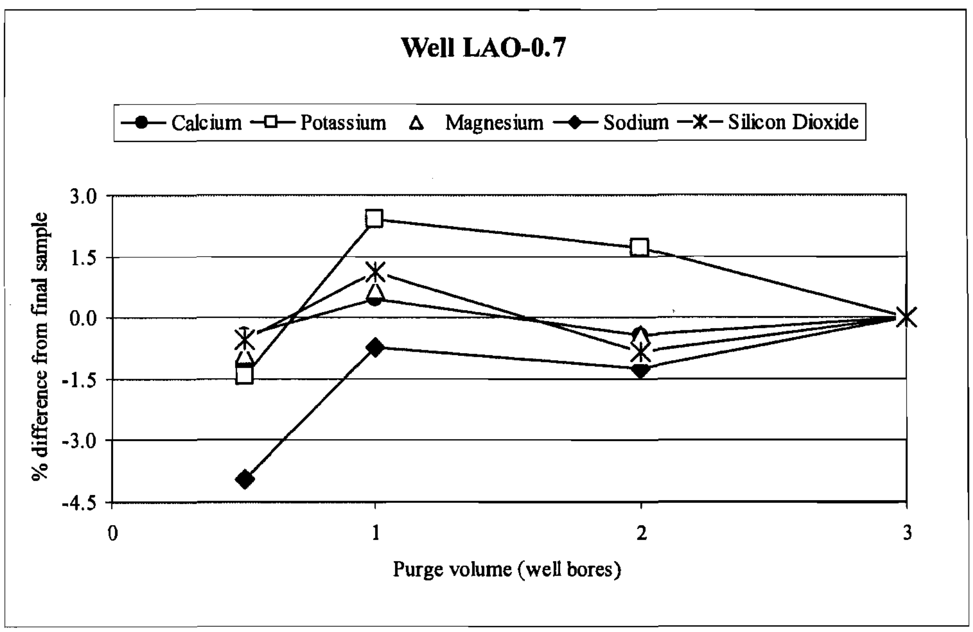

Figure 38. LAO-0.7 Ca, K, Mg, Na and SiO_2 results compared to the final sample. Concentrations changed little.

LAO-3A

For LAO-3A, I collected data on 4/25/02 and 6/05/02. I collected chemistry and manual readings on both dates, and also hydrolab data on 6/05/02.

Drawdown for LAO-3A for the sampling event on 4/25/02 was variable and at most 0.07 ft with a purge rate of 0.33 LPM (Figure 39). For the sampling event on 6/05/02 drawdown was stable throughout at approximately 0.03 ft with a purge rate of 0.33 LPM (Figure 40). Manual readings for turbidity for both sampling events, based on the NMED criteria, stabilized after two well bores purged. The readings were at around 2.5 NTU throughout both the sampling events (Figures 41 and 42). The Hydrolab readings were higher, and did not stabilize. Based on the problem I had with the hydrolab, these data are more than likely no good. The turbidity readings using the Hydrolab were jumping around more, though most of the readings were between 4 and 8 NTU (Figure 42). A possible reason for the difference in turbidity readings could be, as mentioned earlier, the sensitivity of the turbidity probe on the Hydrolab to light.

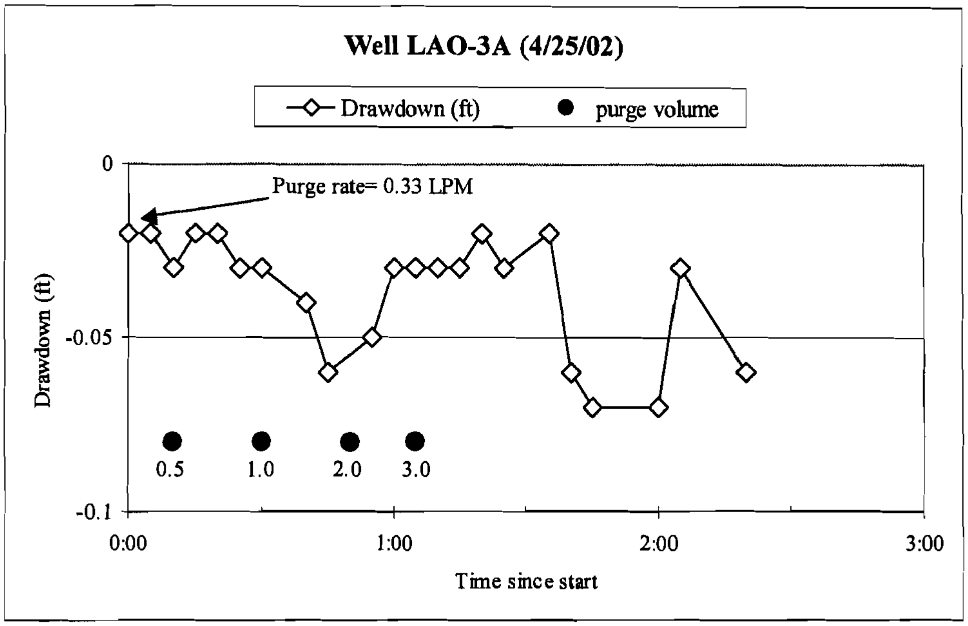

Figure 39. LAO-3A (4/25/02) drawdown. Solid circles indicate the number of well bores purged.

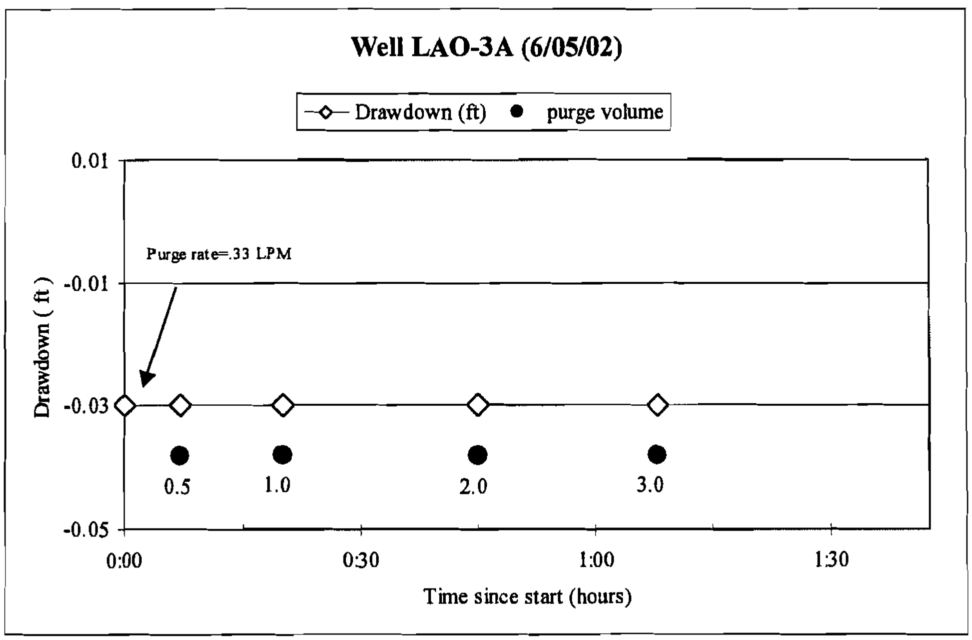

Figure 40. LAO-3A (6/05/02) drawdown. Solid circles indicate the number of well bores purged.

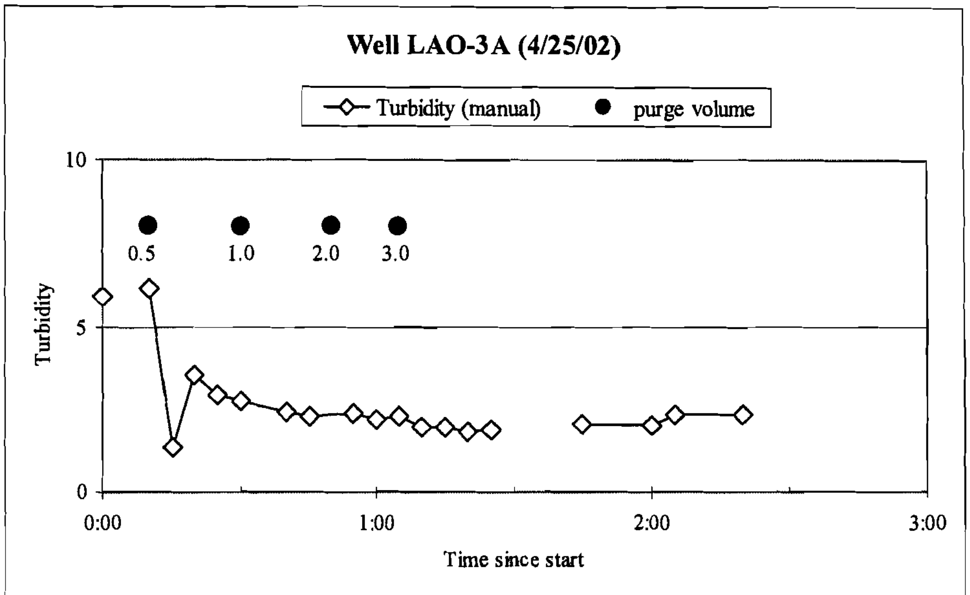

Figure 41. LAO-3A (4/25/02) turbidity results from manual readings. Solid circles indicate the number of well bores purged.

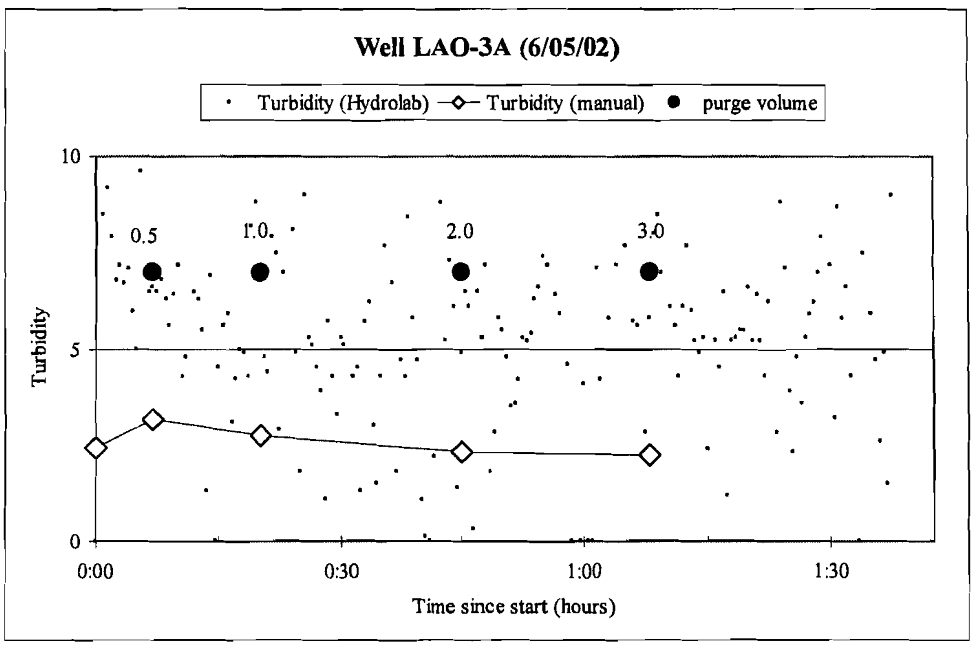

Figure 42. LAO-3A (6/05/02) turbidity results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

Both the manual and Hydrolab readings for pH and EC were stable throughout the sampling event. The manual readings for pH on 4/25/02 stabilized at approximately 7.3, and on 6/05/02 the manual readings stabilized at around 7.1 (Figures 43 and 44). The

Hydrolab values were slightly lower than the manual values at around 6.9 (Figure 44). Manual readings for EC on 4/25/02 were stable at around 307 µS/cm (Figure 45). EC for both the Hydrolab and manual readings taken on 6/05/025 were stable at approximately 275 µS/cm (Figure 46). Temperature for LAO-3A on 4/25/02 gradually decreased throughout the sampling event (Figure 47). For the sampling event on 6/05/02, temperature gradually increased throughout the event (Figure 48). A possible explanation for the difference is that 4/25/02, was cloudy, cool, and drizzling, while 6/05/02 was a hot summer day. Based on NMED criteria, both the manual readings and the Hydrolab temperature readings (Figure 48) showed stabilization during the sampling event.

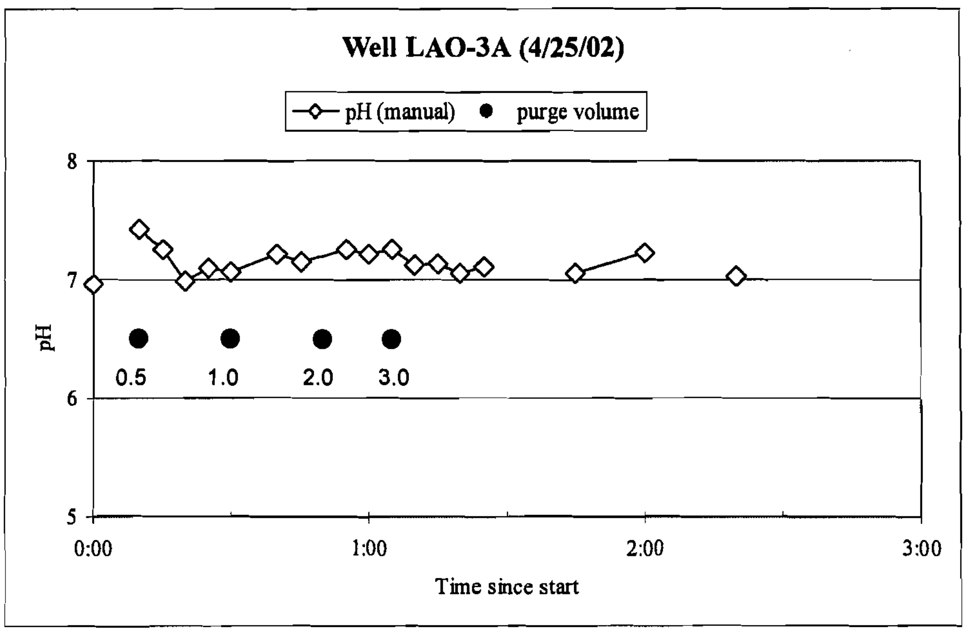

Figure 43. LAO-3A (4/25/02) pH results from manual readings. Solid circles indicate the number of well bores purged.

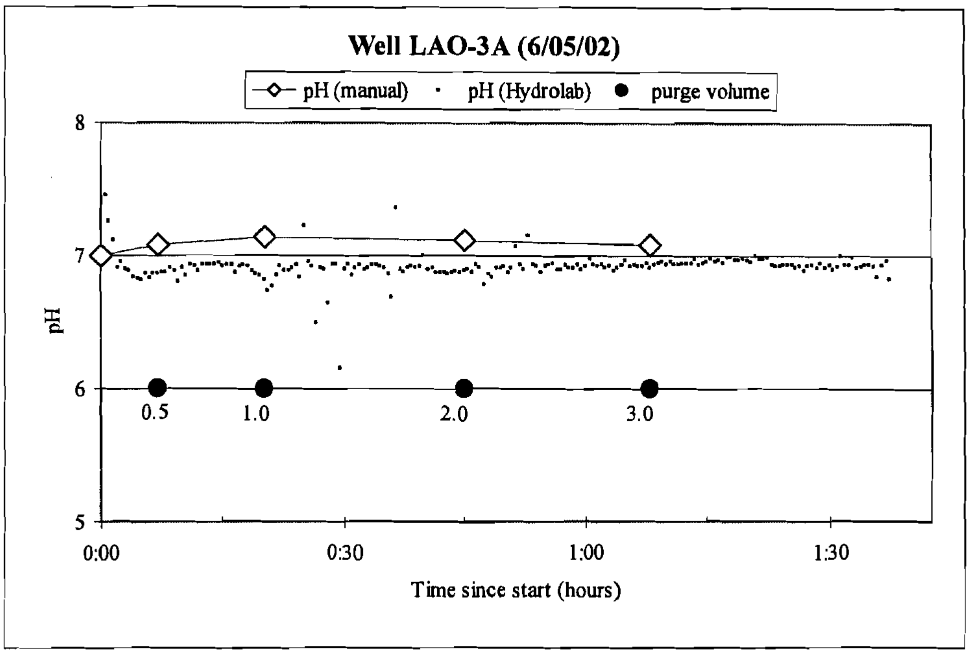

Figure 44. LAO-3A (6/05/02) pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

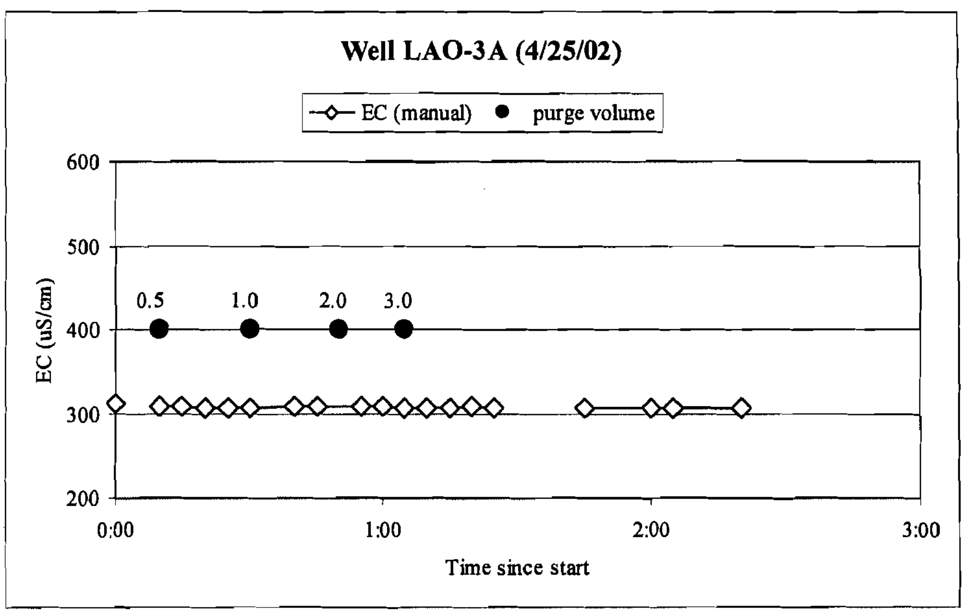

Figure 45. LAO-3A (4/25/02) Conductance results from manual readings. Solid circles indicate the number of well bores purged.

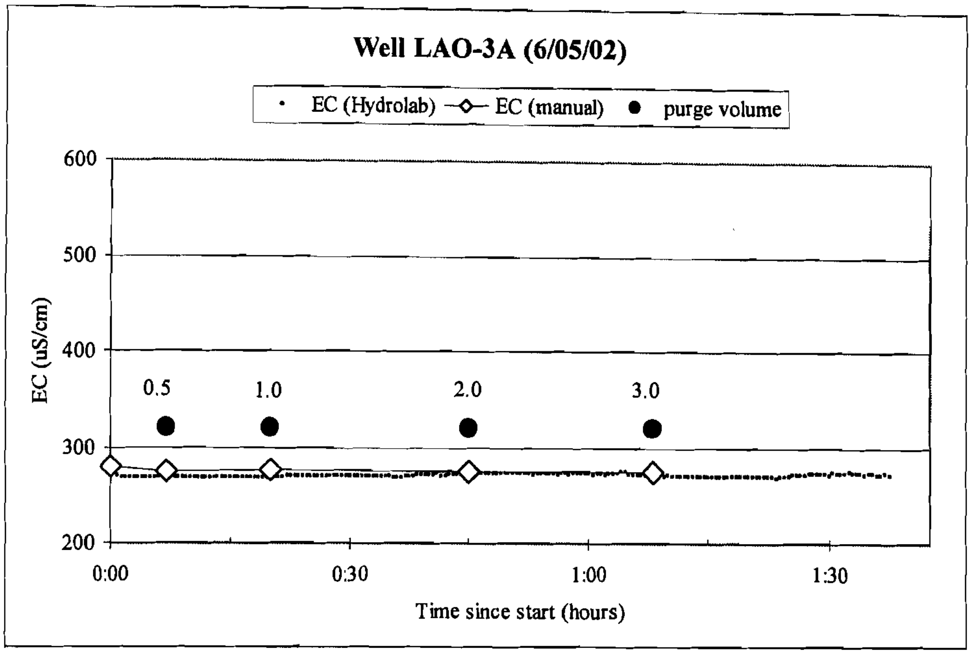

Figure 46. LAO-3A (6/05/02) conductance results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

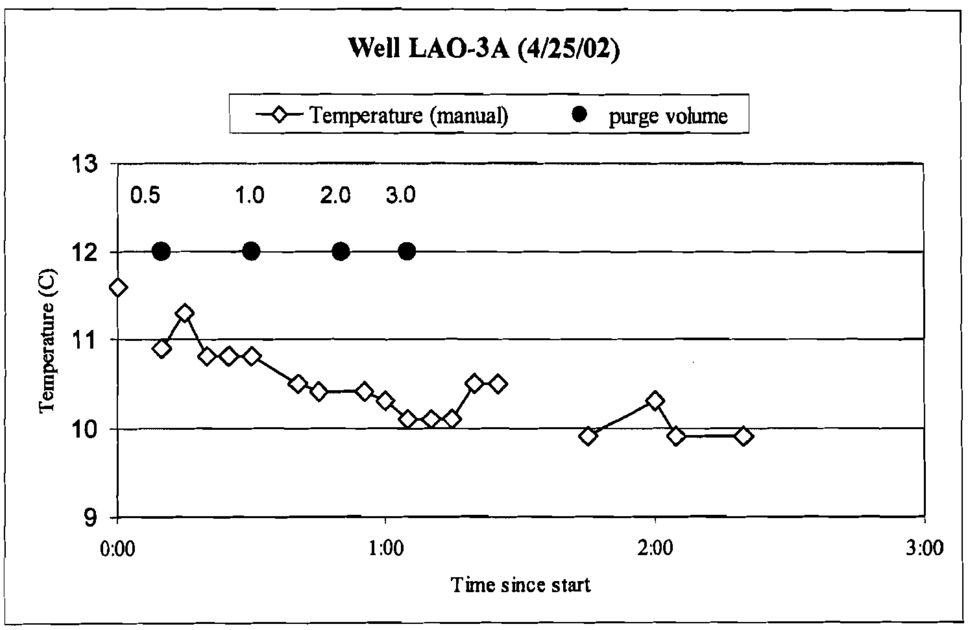

Figure 47. LAO-3A (4/25/02) temperature results from manual readings. Solid circles indicate the number of well bores purged.

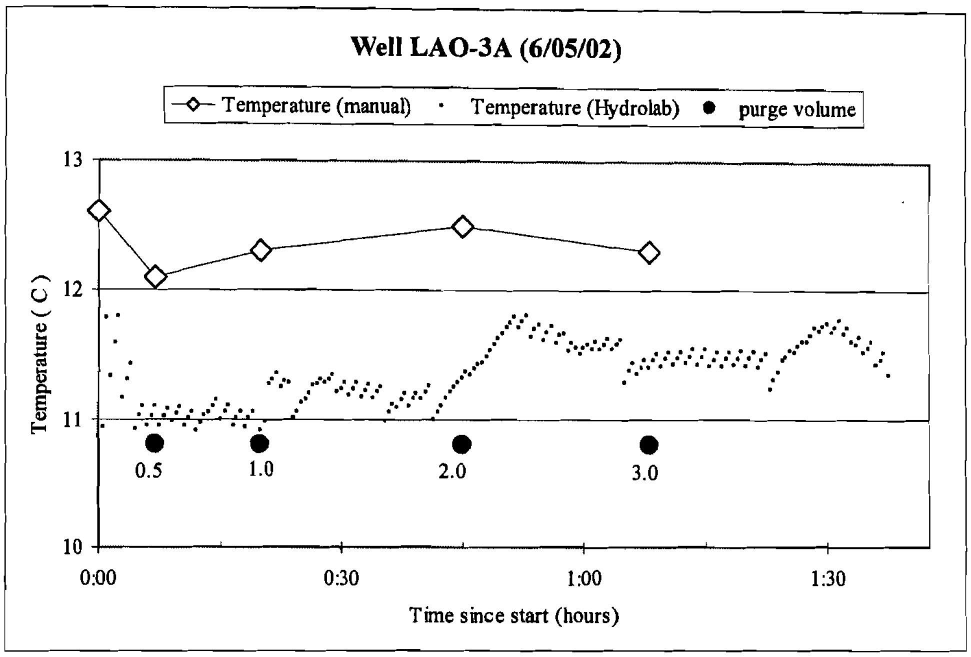

Figure 48. LAO-3A (6/05/02) temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

The DO readings for this well are more stable than LAO-C and LAO-0.7, but are probably not representative of the formation water. The amount of difference seen between the three wells suggests problems with the sensor on the Hydrolab as well as the problems that occurred with the setup (Figure 49). The ORP readings showed stabilization the whole time at around 325 mV (Figure 50).

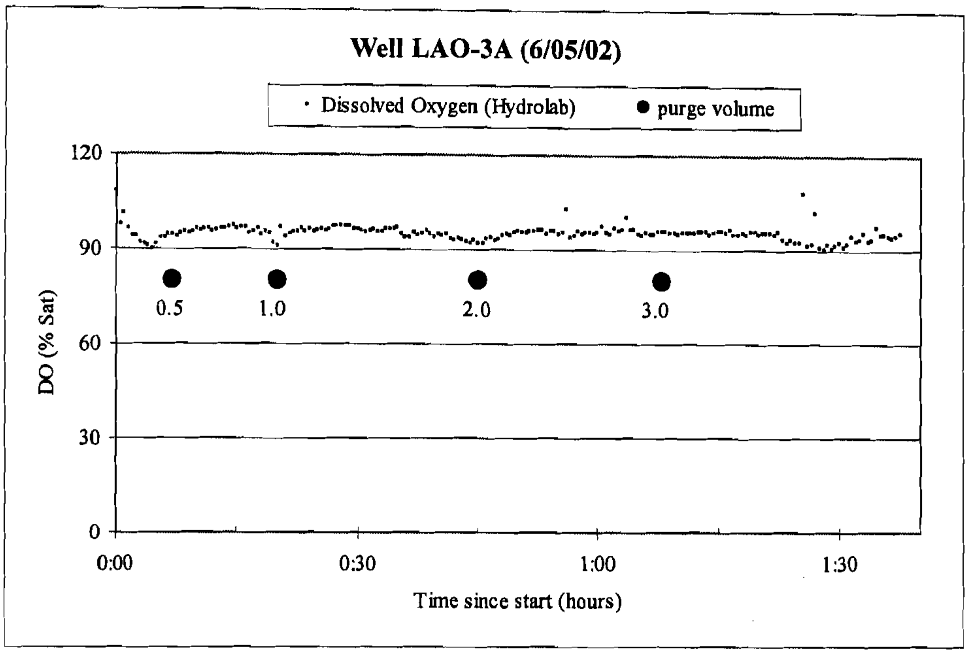

Figure 49. LAO-3A (4/25/02) dissolved oxygen results from the Hydrolab. Solid circles indicate the number of well bores purged.

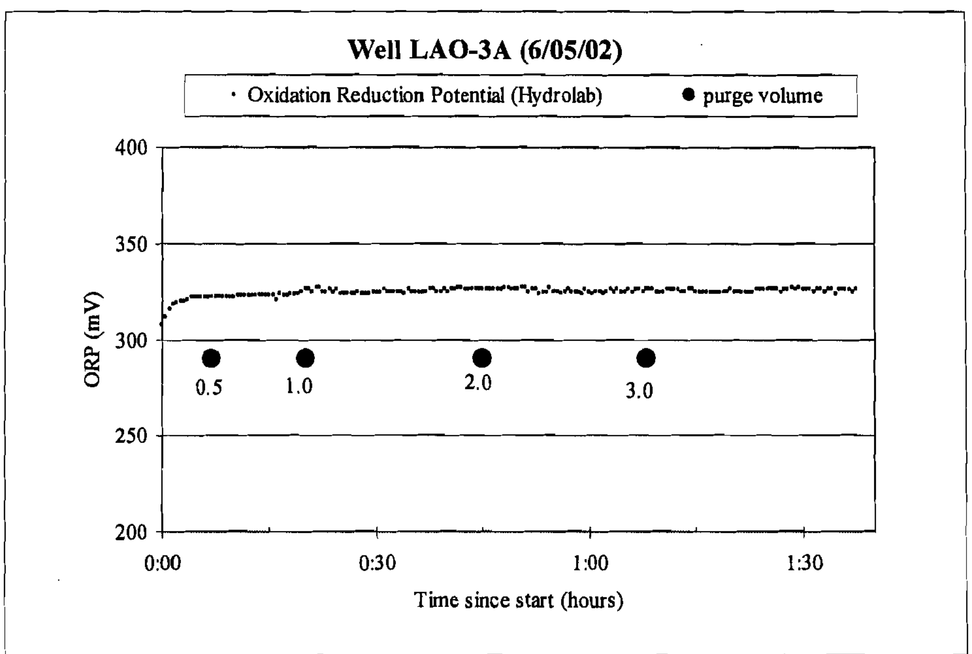

Figure 50. LAO-3A (6/05/02) oxidation-reduction potential results from the Hydrolab. Solid circles indicate the number of well bores purged.

The chemistry results for metals show Al, Fe, Zn and Co stabilized after the first sample (Figures 51 and 52). The concentration of Co on 4/25/02 dropped below the detection limit after the first sample. For the samples collected on 6/05/02, Fe and Zn dropped below the detection limit after one-half well bore purged. Ba and Sr on both sampling dates, and Mo on 6/05/02 showed no significant change in concentration throughout the sampling event (Figures 53 and 54). Note the large differences between dates in the percent differences. On 4/25/02 the initial concentrations of Fe and Al are around 400% different than the final sample, while on 6/05/02 the initial concentrations of Fe and Al were approximately 90% different from the final sample. This may be explained by the difference in turbidity ranges. For 4/25/02 the turbidity range was higher, going from 6 to 2 NTU, while on 6/05/02, the turbidity range went from 3 to 2 NTU.

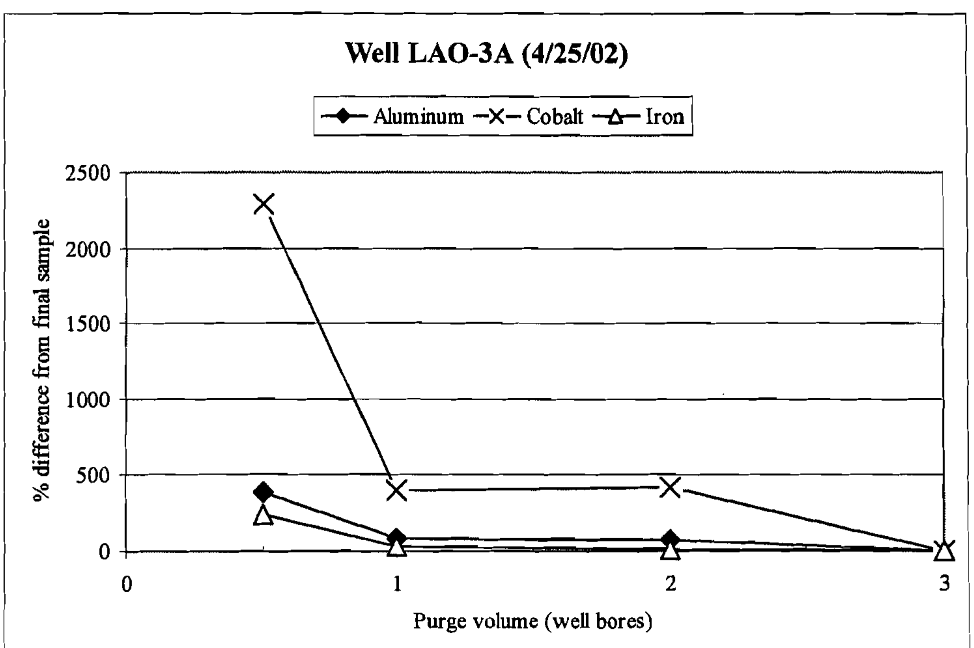

Figure 51. LAO-3A (4/25/02) Al, Fe, and Co results compared to the final sample.

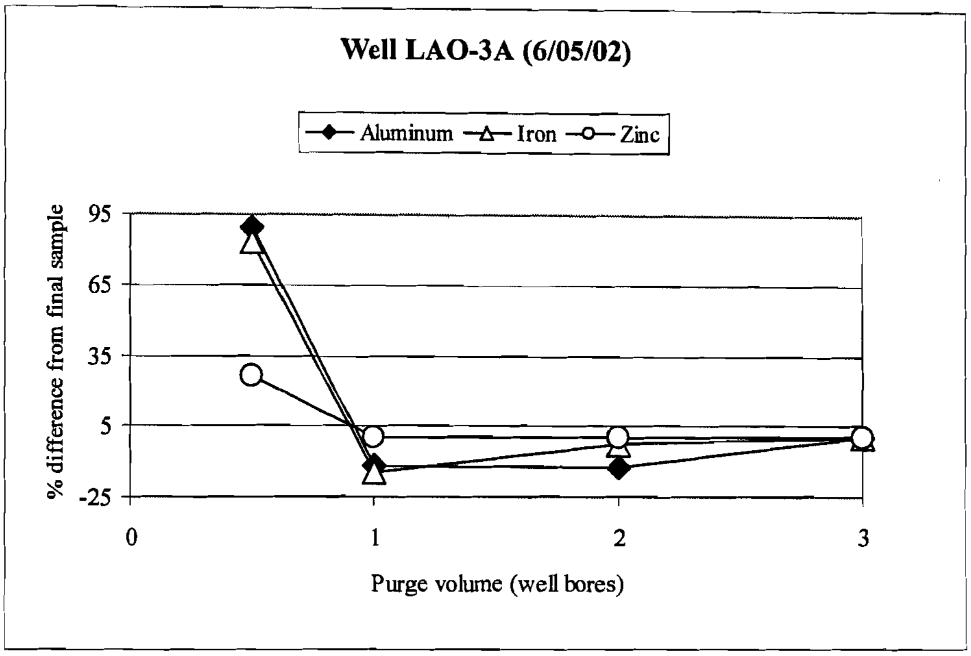

Figure 52. LAO-3A (6/05/02) Al, Fe, and Zn results compared to the final sample.

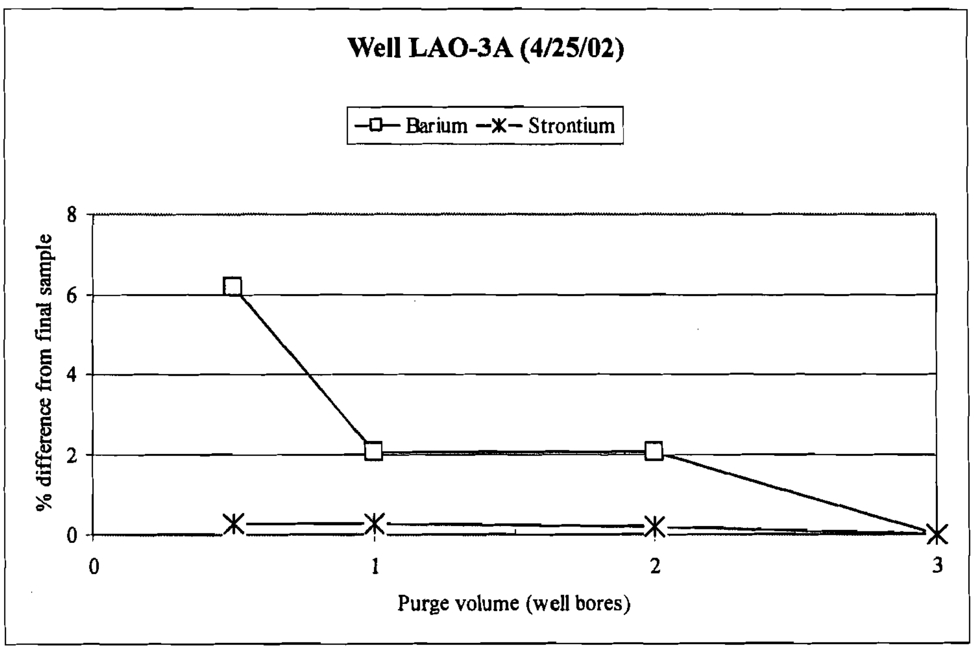

Figure 53. LAO-3A (4/25/02) Ba and Sr results compared to the final sample.

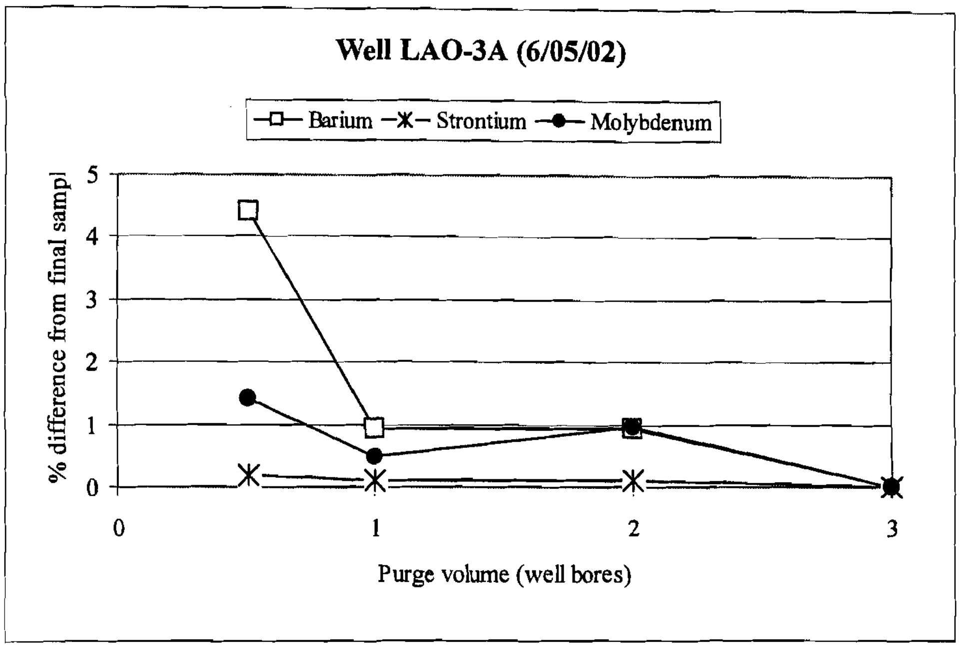

Figure 54. LAO-3A (6/05/02) Ba, Sr and Mo results compared to the final sample.

For the sampling event on 4/25/02, chloride showed an increase of approximately 50%, while fluoride showed a decrease of around 225%. The concentrations for these changed little (Figure 55). For the event on 6/05/02, chloride and fluoride show an increase (Figure 56). The only constituent of interest is nitrate, (and concentrations are exaggerated on the graph), the concentrations change slightly; these concentrations are 0.72 mg/l, 0.74 mg/l, 0.73 mg/l, and 0.73 mg/l.

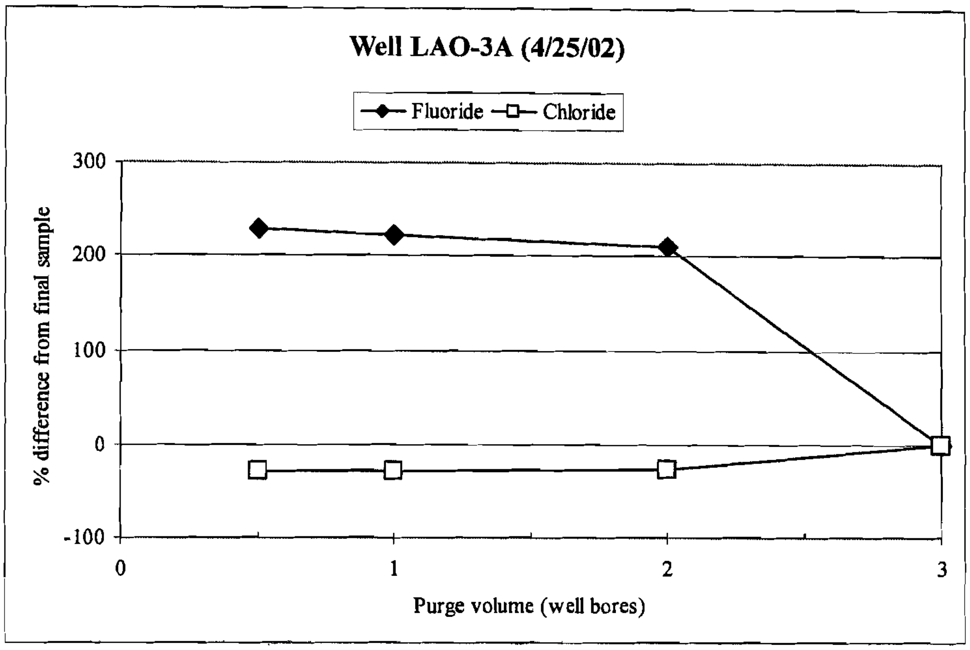

Figure 55. LAO-3A (4/25/02) chloride and fluoride results compared to the final sample. Concentrations changed little.

On 4/25/02, nitrate-nitrite as nitrogen, sulfate, total alkalinity, and total dissolved solids showed no significant changes. Total phosphorous showed as much as 16 % change, although the concentration changed little (Figure 57). For the event on 6/05/02, nitrate-nitrite as nitrogen and sulfate, show an increases (Figure 56).

On 6/05/02 the graph for total alkalinity and total phosphorous shows a range of changes (Figure 58). Total alkalinity changes at most 12% from the final sample, while total phosphorous shows slight changes in concentrations of 0.2 mg/l, 0.2 mg/l, 0.18 mg/l, and 0.24 mg/l. Total dissolved solids show no significant changes. The results for the major cations and anions, except for silica on 4/25/02, and K on 6/05/02, showed little change (Figures 59 and 60). The concentrations for silica and K changed little.

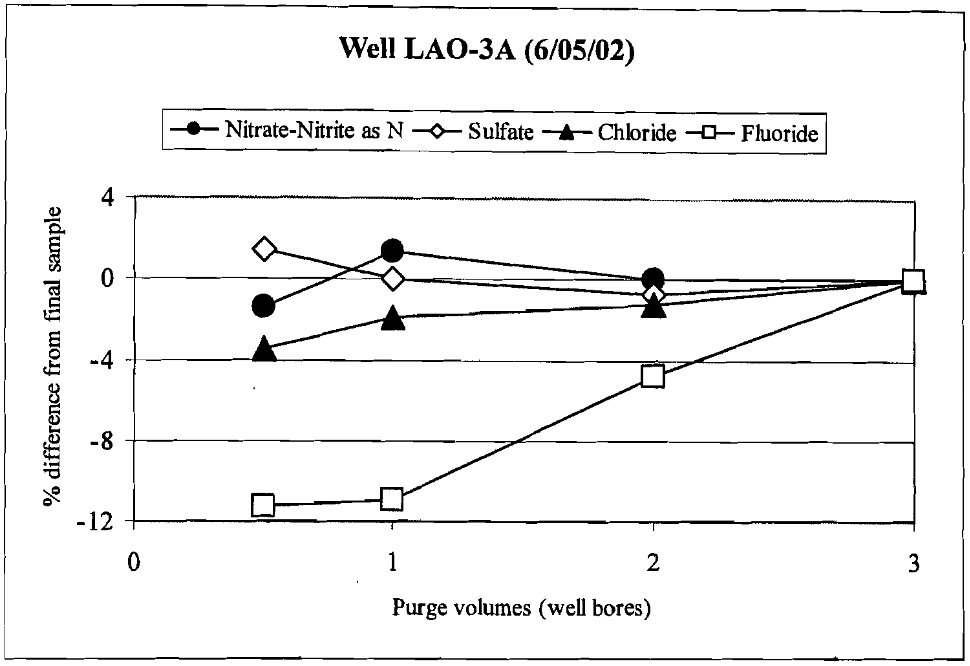

Figure 56. LAO-3A (6/05/02) nitrate-nitrite as nitrogen, chloride and fluoride results compared to the final sample. Concentrations changed little.

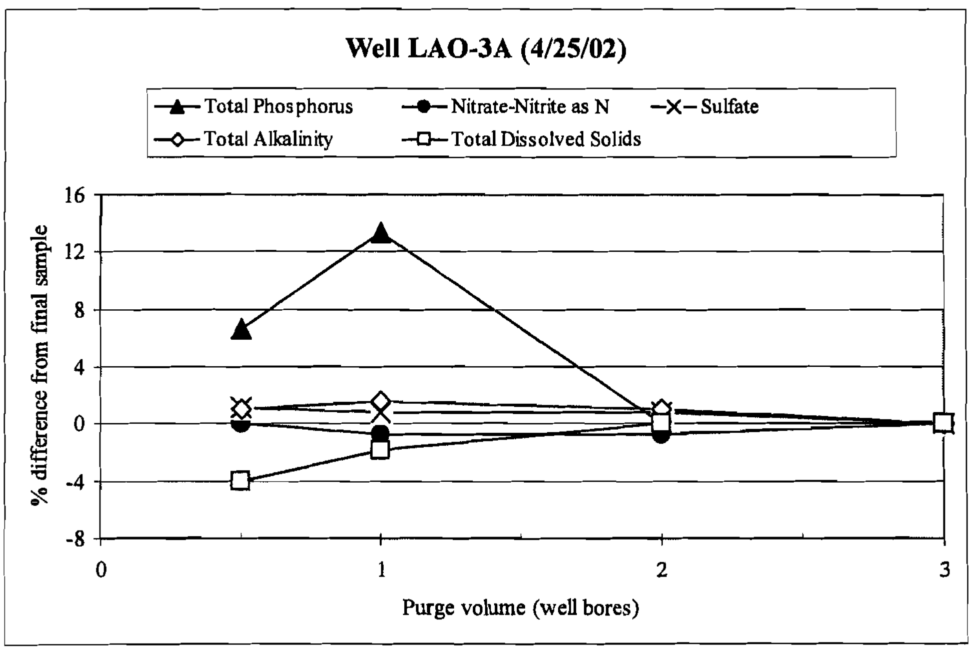

Figure 57. LAO-3A (4/25/02) total alkalinity, total phosphorous, total dissolved solids, nitrate-nitrite as N, and sulfate results compared to the final sample. Concentrations changed little.

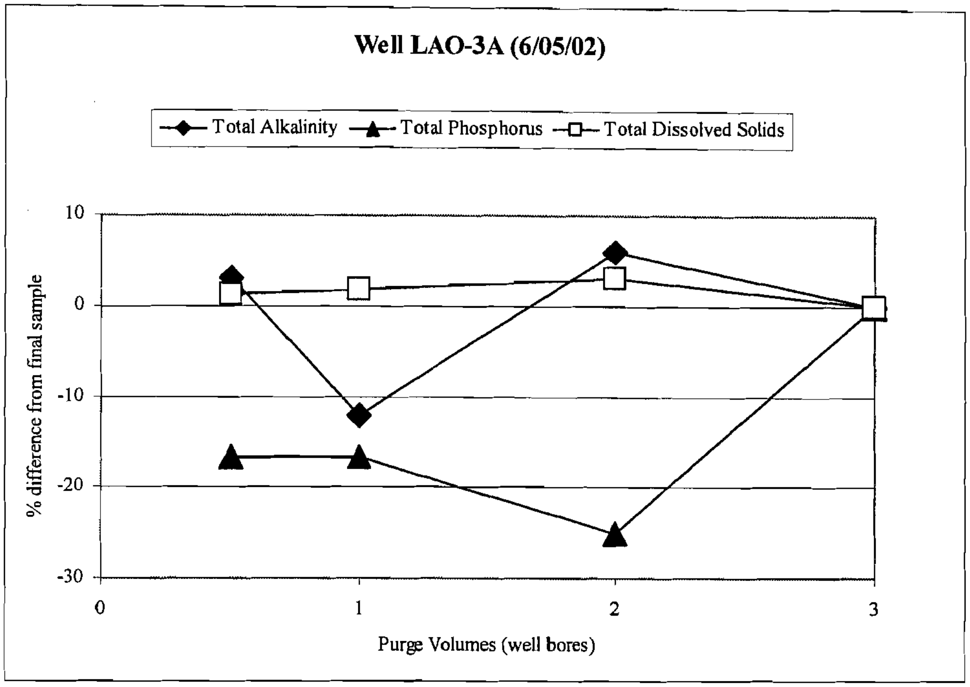

Figure 58. LAO-3A (6/05/02) total alkalinity, total phosphorous, and total dissolved solids results compared to the final sample.

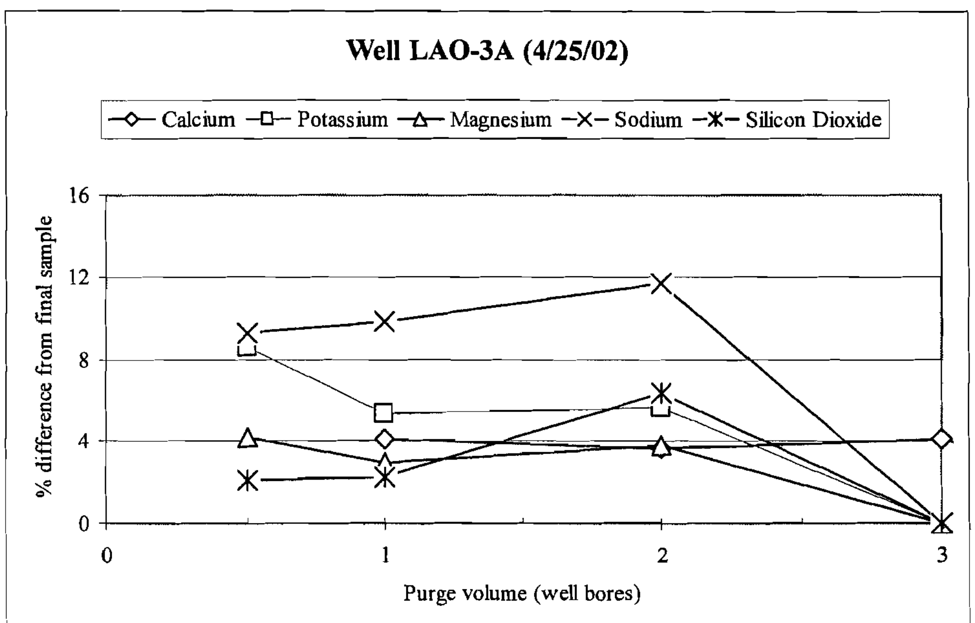

Figure 59. LAO-3A (4\25\02) Ca, K, Mg, Na and SiO_2 results compared to the final sample.

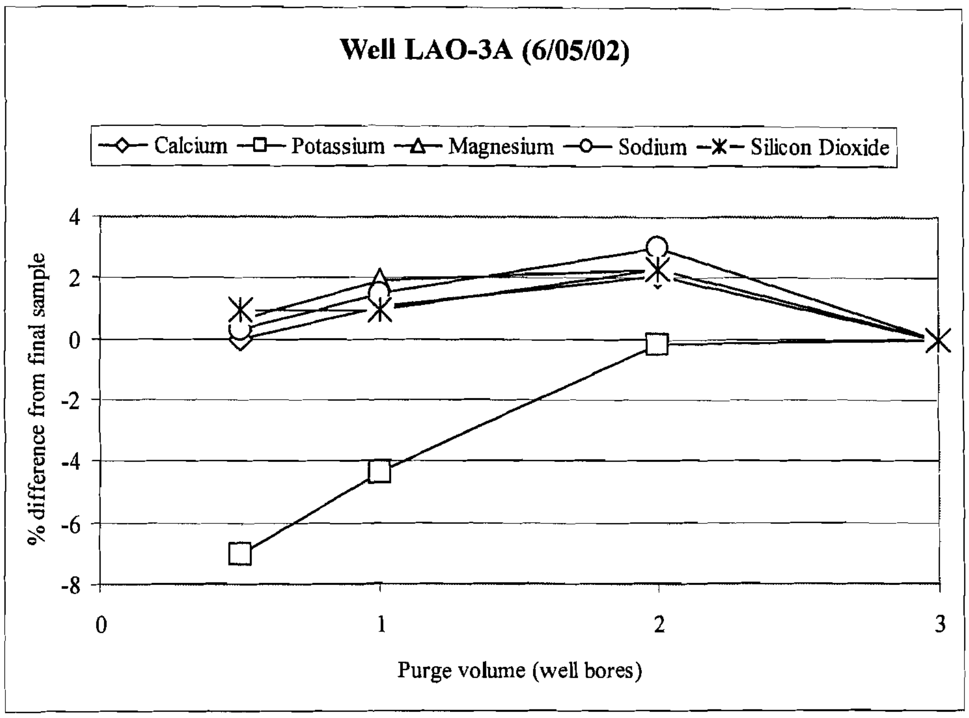

Figure 60. LAO-3A (6/05/02) Ca, K, Mg, Na and SiO_2 results compared to the final sample.

Mortandad Canyon

MCO-5

For MCO-5, drawdown stabilized by one well bore purged at approximately 0.6 ft at a purge rate of 0.33 LPM (Figure 61). This rate is lower than the 0.3 ft NMED recommends for drawdown on a well.

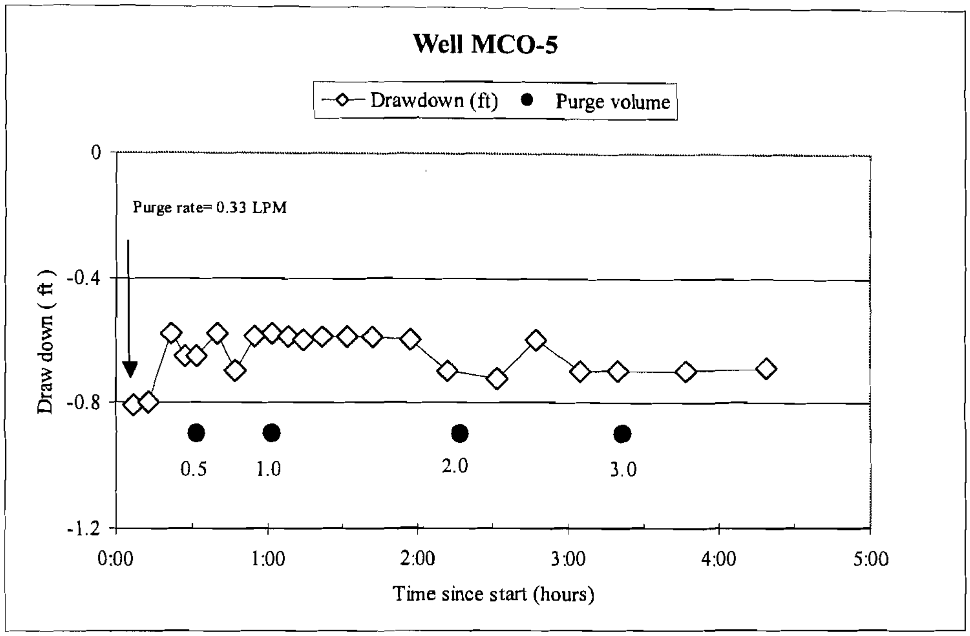

Figure 61. MCO-5 drawdown. Solid circles indicate the number of well bores purged.

The manual readings for turbidity (Figure 62) did not stabilize until one well bore purged, but the readings were very low, ranging from 1.98 to 0.69 NTU throughout the sampling event. This well did not have Hydrolab turbidity results because sunlight prevented the readings. For this well the turbidity and Al and Fe trends are not similar in the sense that turbidity at MCO-5 is lower overall, and does decrease, but less than the other wells. While Al and Fe levels are lower than most other wells, and decrease half as much as the other wells (in particular Los Alamos Canyon wells).

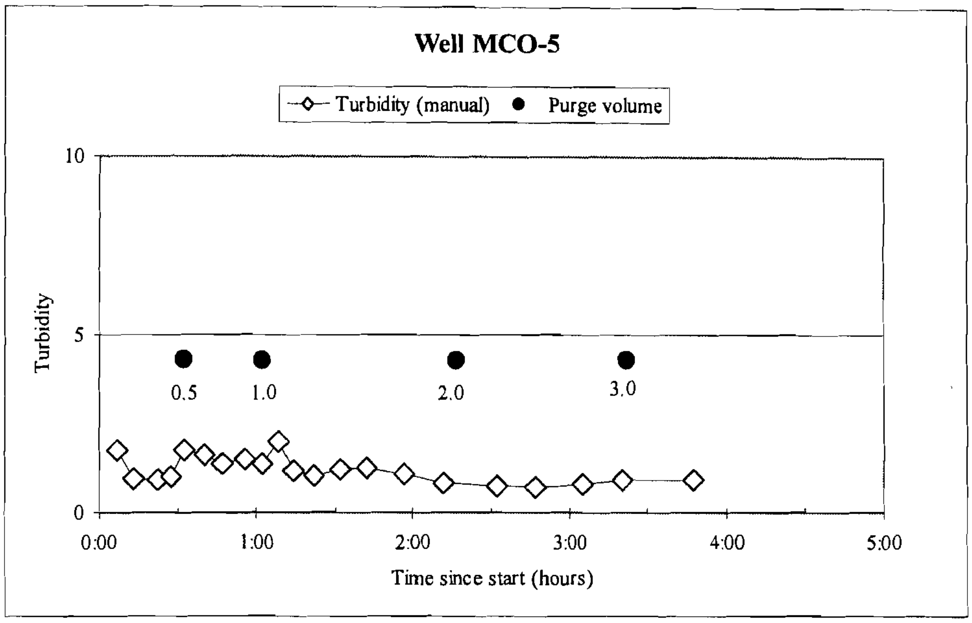

Figure 62. MCO-5 turbidity results from the manual readings. Solid circles indicate the number of well bores purged.

The manual and Hydrolab readings for pH and EC showed stabilization throughout the event based on NMED criteria (Figures 63 and 64). Although the last reading did drop more than 10%, this percentage may indicate a problem with the manual reading. The reason for this is that the probe may have lost its calibration in the field. Temperature for MCO-5 was variable and gradually increased throughout the sampling event, showing no stabilization (Figure 65). DO and ORP readings for MCO-5 did stabilize throughout the sample event (Figures 66 and 67). As mentioned earlier, NMED does not have stabilization criteria for ORP.

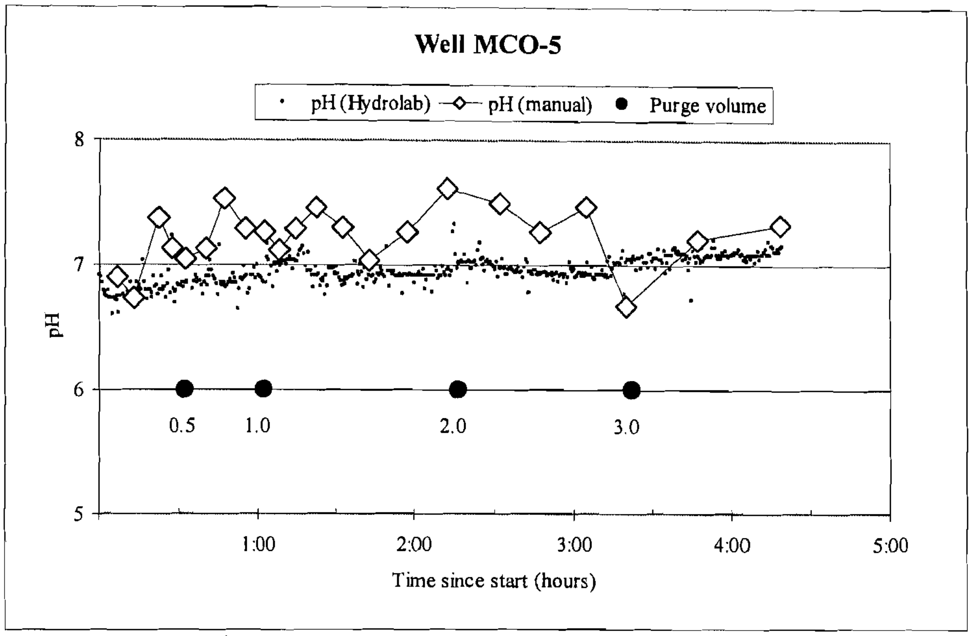

Figure 63. MCO-5 pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

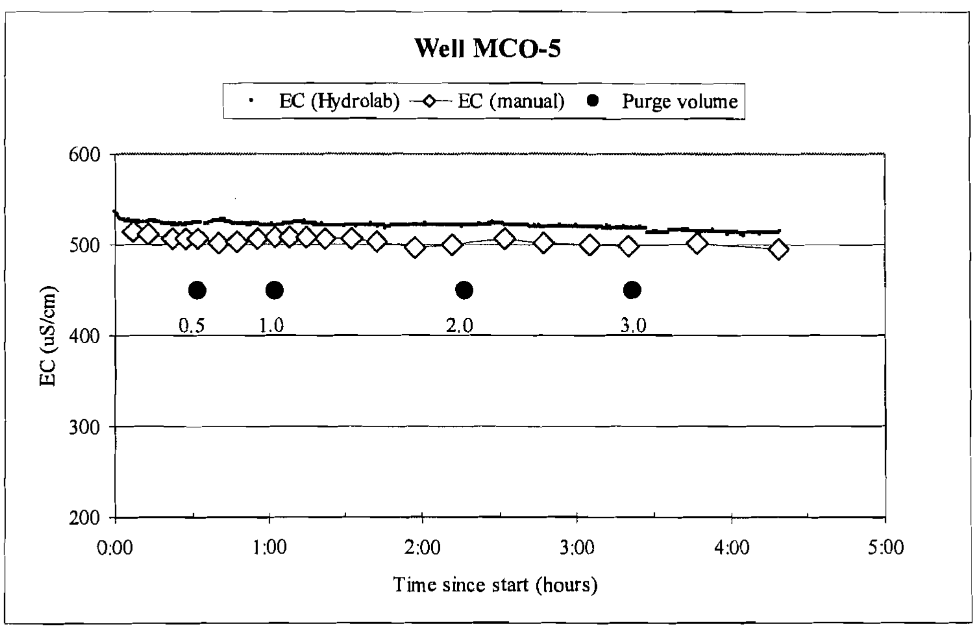

Figure 64. MCO-5 conductance results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

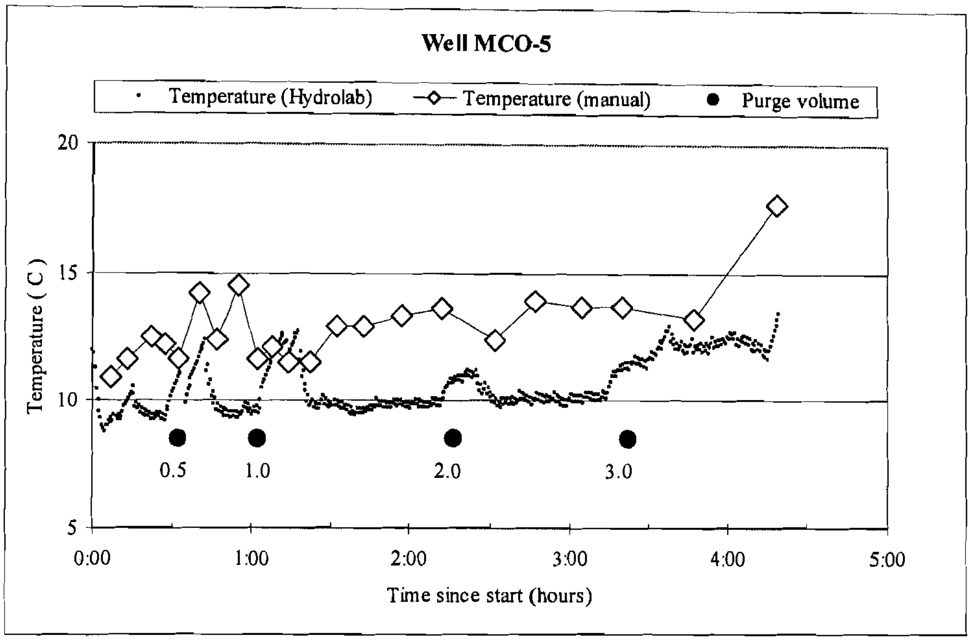

Figure 65. MCO-5 temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

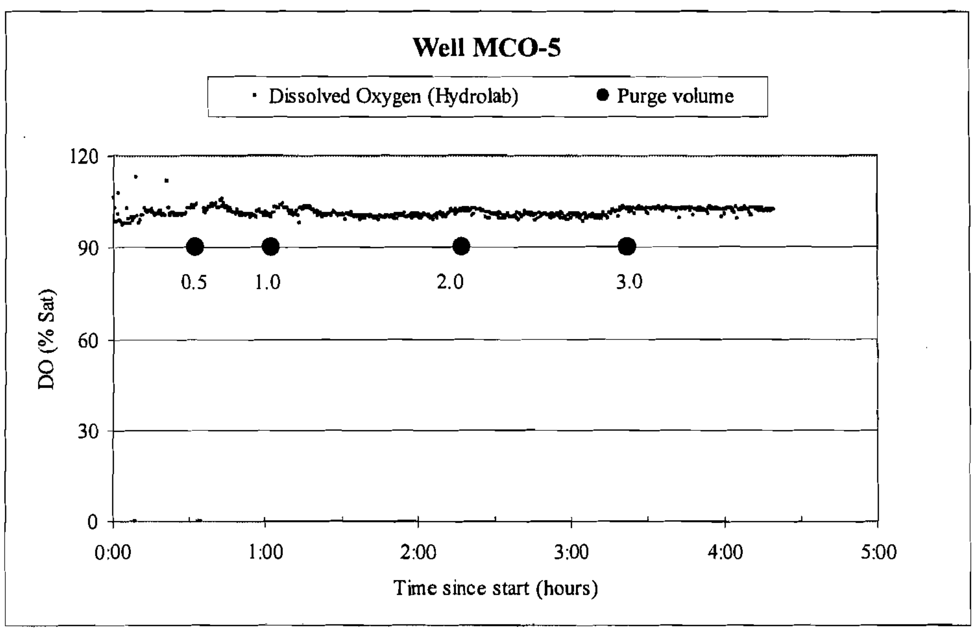

Figure 66. MCO-5 dissolved oxygen results from the Hydrolab. Solid circles indicate the number of well bores purged.

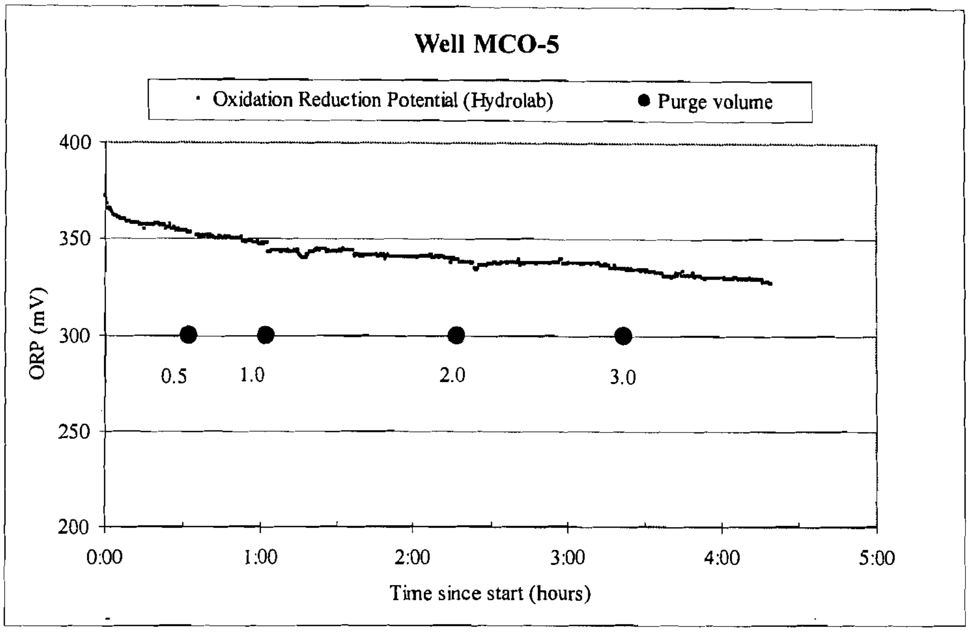

Figure 67. MCO-5 oxidation-reduction potential results from the Hydrolab. Solid circles indicate the number of well bores purged.

The metals analysis for MCO-5 shows the typical decrease in Al and Fe (Figure 68) after the first sample. Fe was not detected after one well bore purged. Ba, B, and Sr exhibit little change (Figure 69). For chloride, sulfate, fluoride and nitrate-nitrite as nitrogen, there was little change after one-half bore purged (Figure 70). The concentrations for nitrate-nitrite as nitrogen vary only slightly after one-half bore; the concentrations were 3.4 mg/l, 3.4 mg/l, 3.3 mg/l and 3.69 mg/l. For total alkalinity and total dissolved solids, there was little change (Figure 71). For total phosphorous, concentrations change little and are near the detection limit (Figure 72). For MCO-5, the concentrations for the major cations and anions change little after one-half well bore purged (Figure 73).

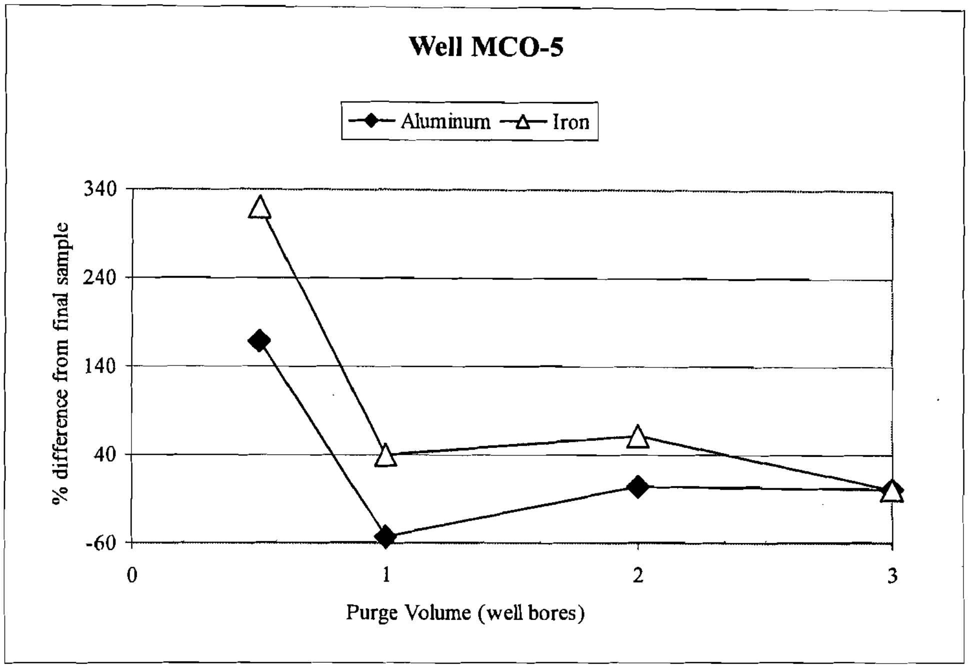

Figure 68. MCO-5 Al and Fe results compared to the final sample Fe is undetected after one-half well bore has been purged.

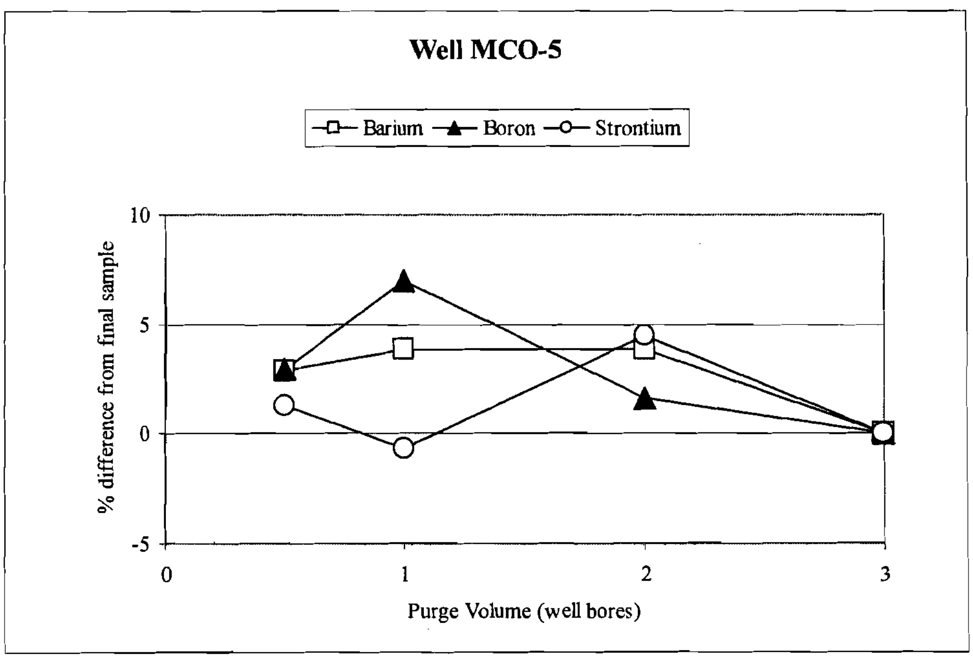

Figure 69. MCO-5 Ba, B and Sr results compared to the final sample. Concentrations changed little.

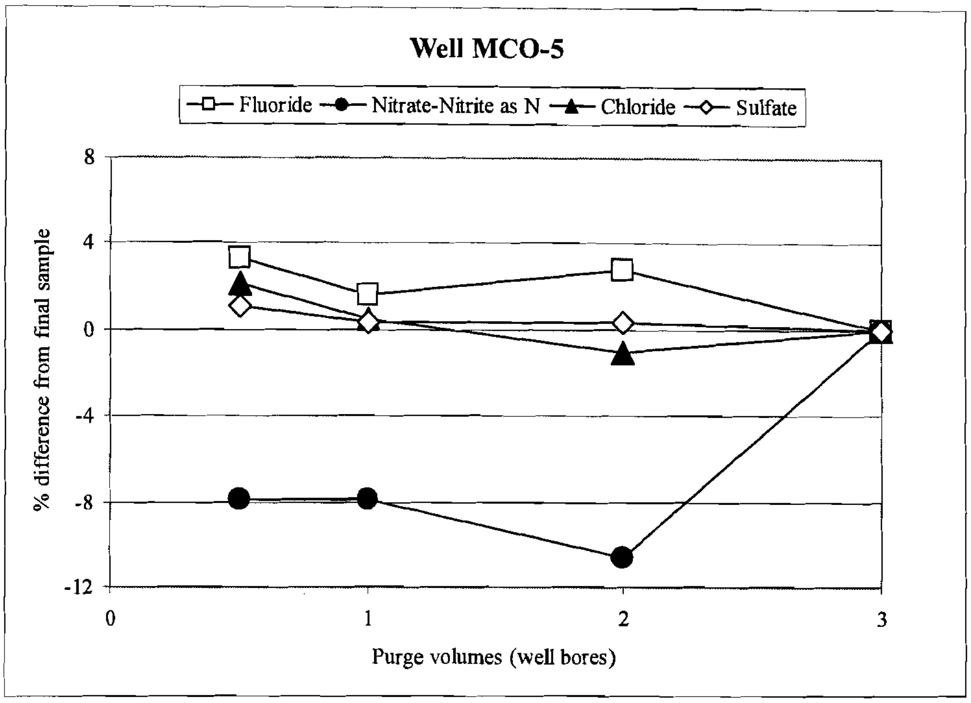

Figure 70. MCO-5 fluoride, nitrate-nitrite as nitrogen, chloride and sulfate results compared to the final sample. Concentrations changed little.

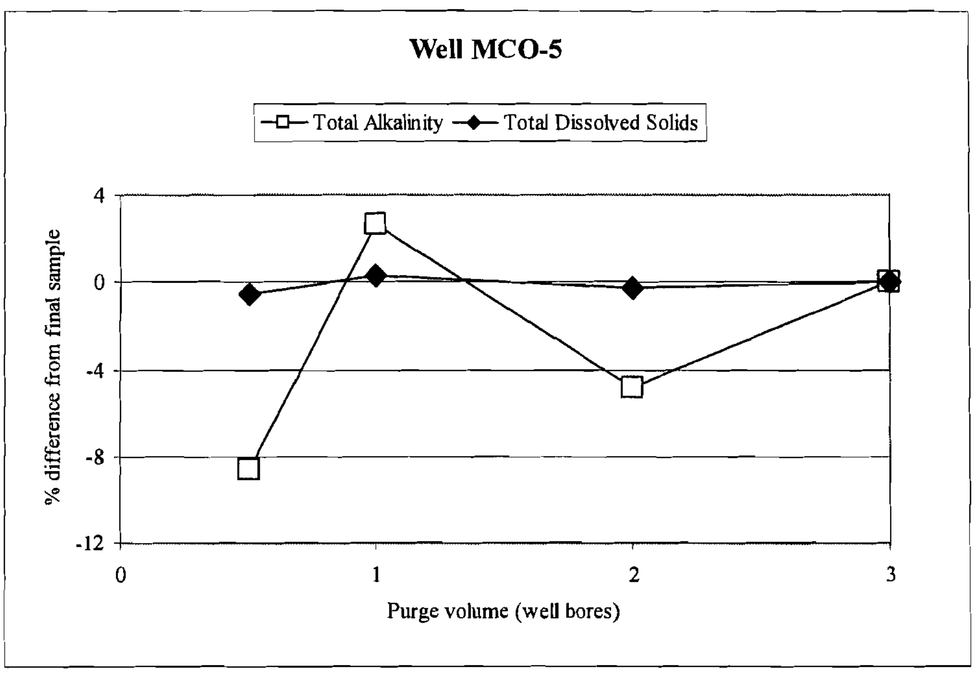

Figure 71. MCO-5 total alkalinity and total dissolved solids results compared to the final sample.

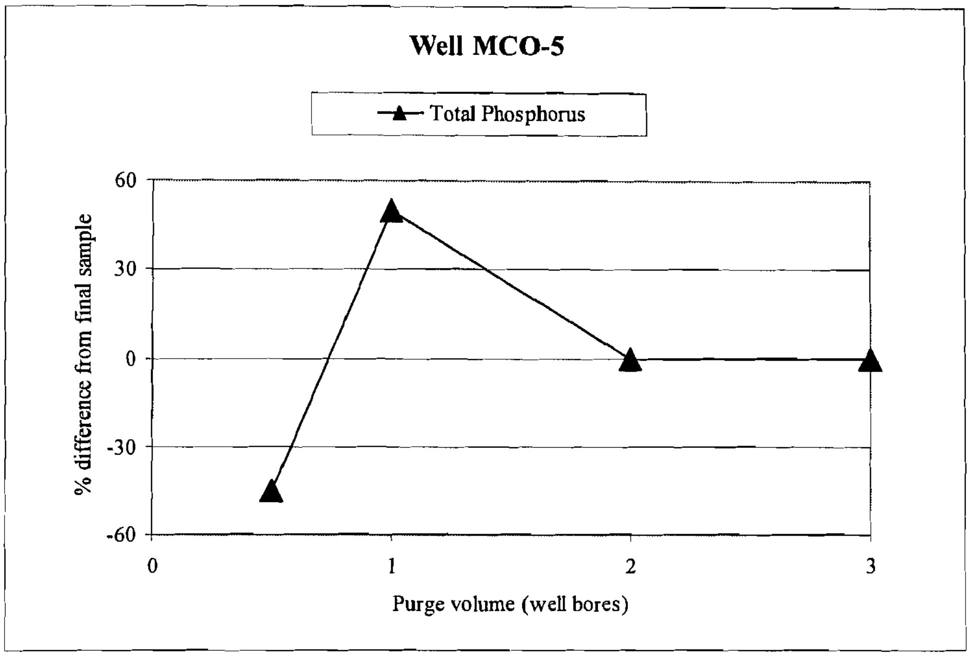

Figure 72. MCO-5 total phosphorous results compared to the final sample.

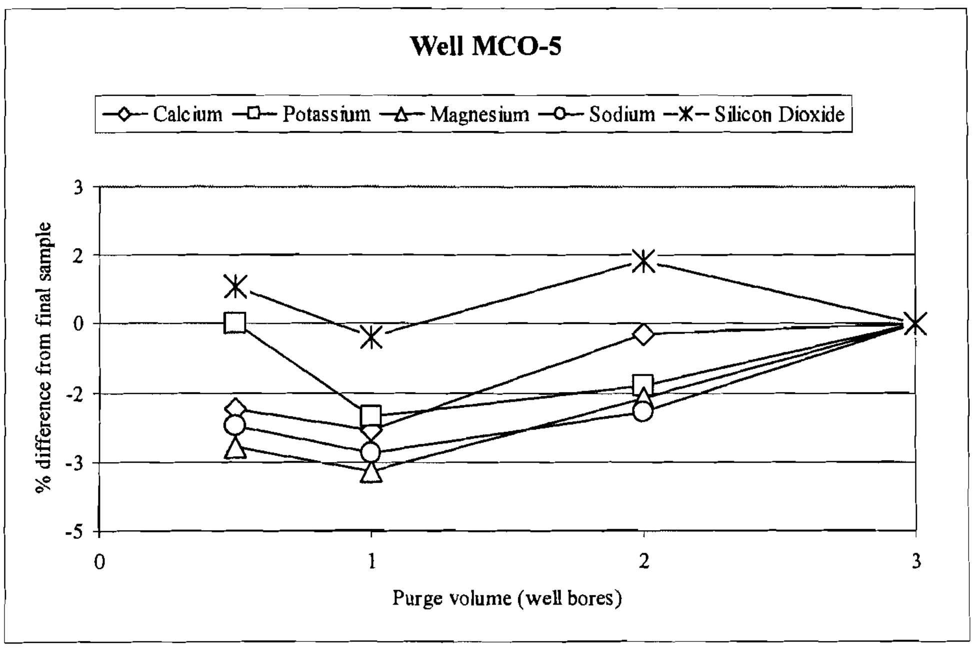

Figure 73. MCO-5 Ca, K, Mg, Na and SiO_2 results compared to the final sample.

MCO-6

For MCO-6, drawdown stabilized after one-half well bore purged at approximately 0.25 ft at a purge rate of 0.24 LPM (Figure 74). The manual readings for turbidity (Figure 75) did not stabilize based on NMED criteria, but the readings were low, ranging from 1.44 to 0.69 NTU throughout the sampling event. This well does not have Hydrolab turbidity results because of issues with sunlight.

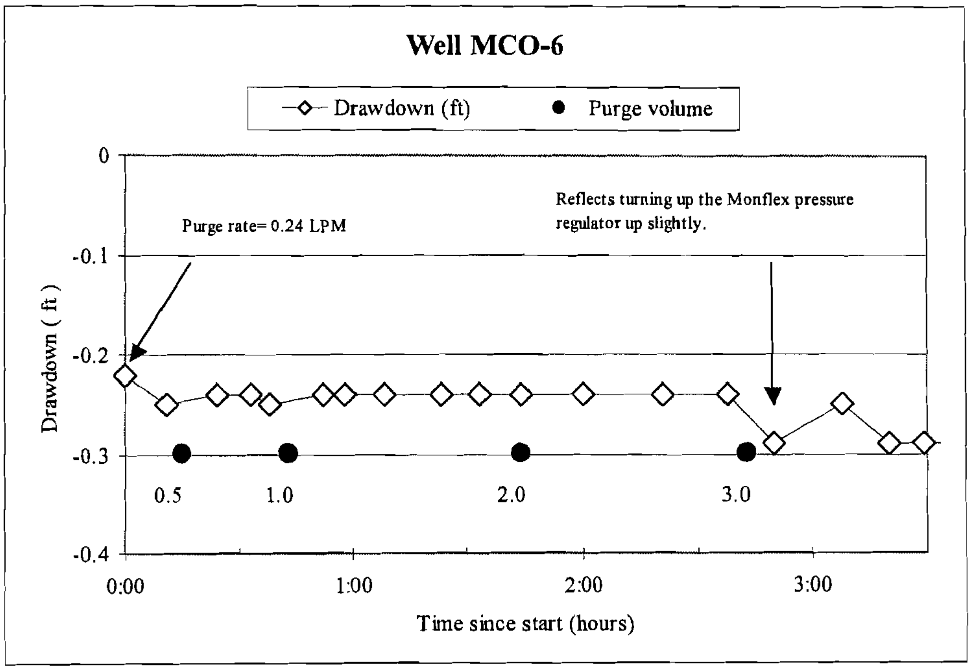

Figure 74. MCO-6 drawdown. Solid circles indicate the number of well bores purged.

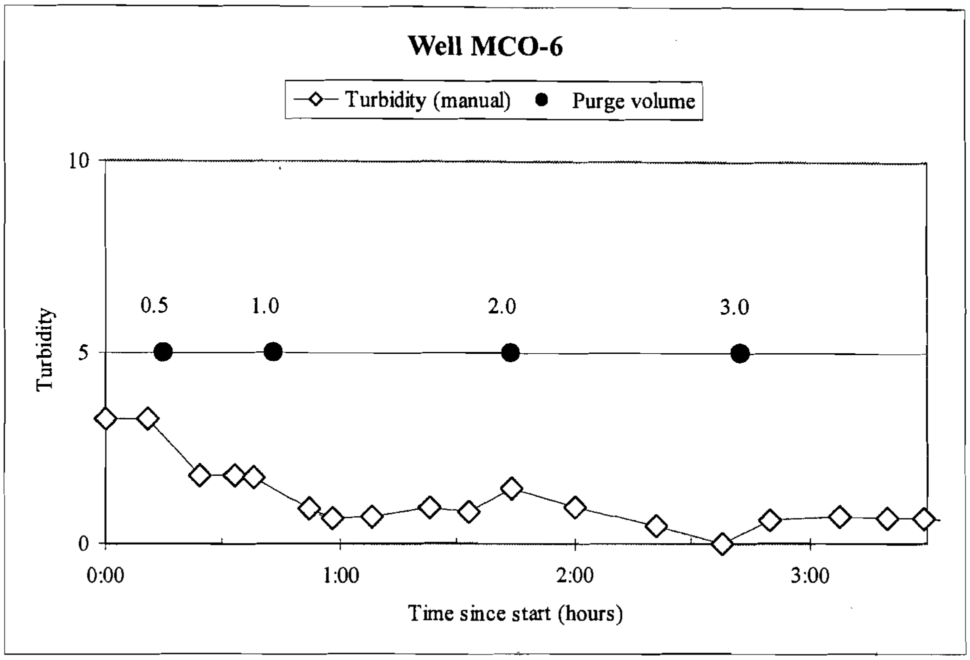

Figure 75. MCO-6 turbidity results from manual readings. Solid circles indicate the number of well bores purged.

The readings for pH and EC from both Hydrolab and manual collection showed stabilization the whole time (Figures 76 and 77). The Hydrolab pH values were slightly lower than the manual pH values and slowly increased throughout the event. EC readings from the Hydrolab were slightly higher than the manual readings of 530 μS/cm, while the manual readings were 500 μS/cm.

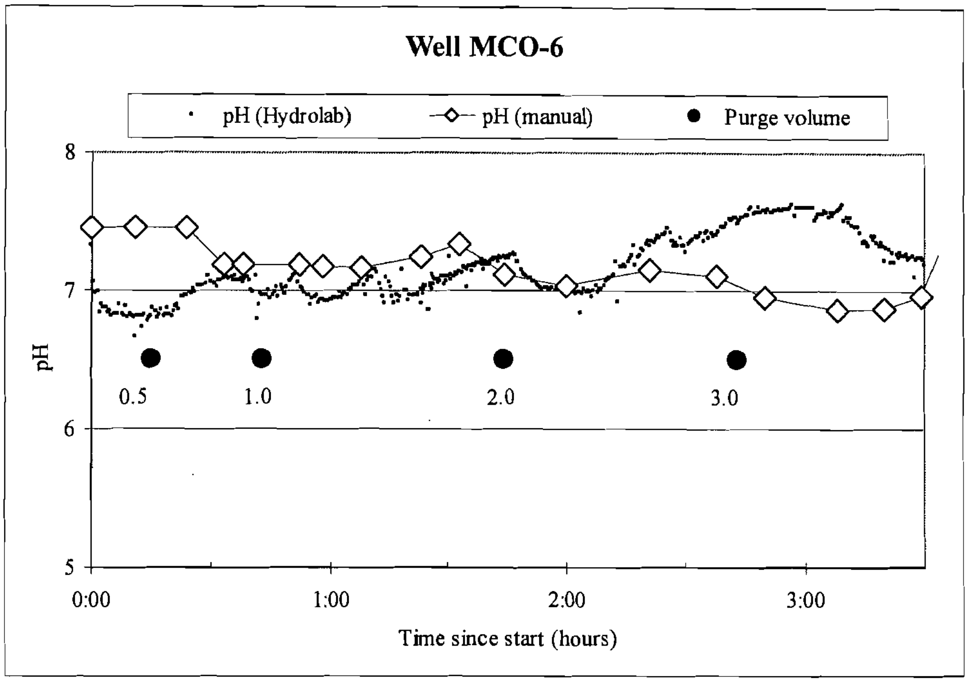

Figure 76. MCO-6 pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

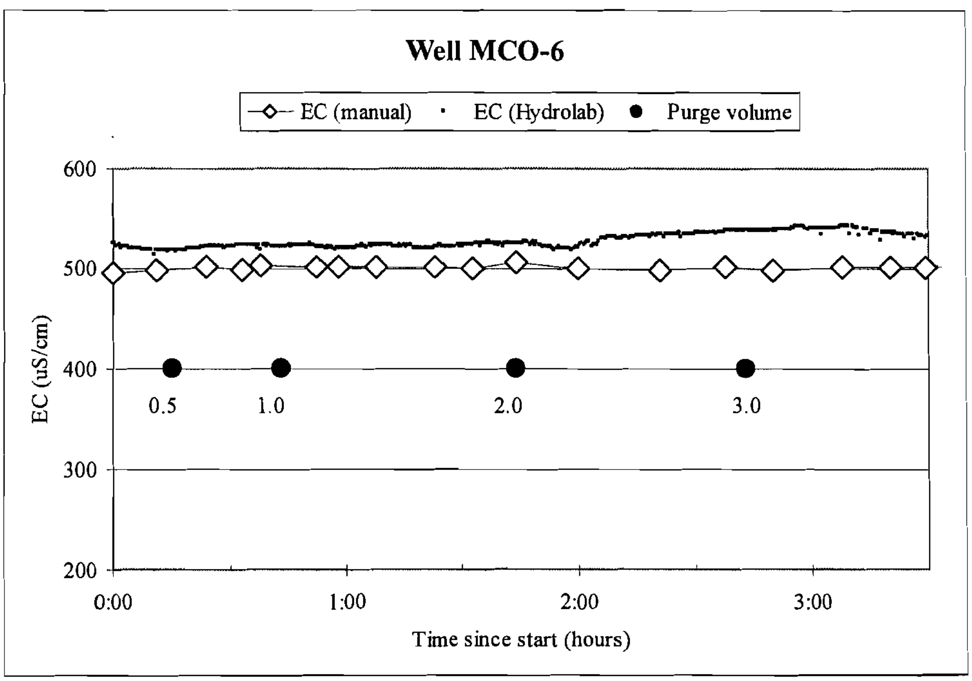

Figure 77. MCO-6 conductance results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

Temperature from the Hydrolab for MCO-6 gradually increased throughout the sampling event, showing no stabilization. The manual readings cycled up and down throughout the event, also showing no stabilization (Figure 78).

DO readings for MCO-6 stabilized the whole time at 100 % saturation (Figure 79). The ORP readings showed a slight decrease throughout the sample event, although stabilization was seen throughout the event at around 325 mV (Figure 80).

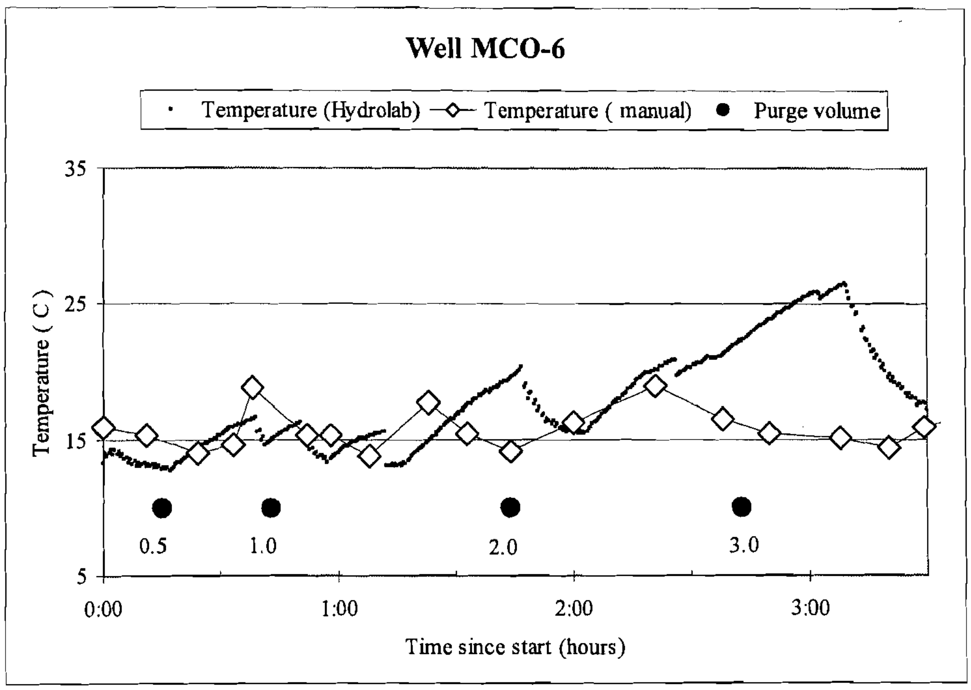

Figure 78. MCO-6 temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

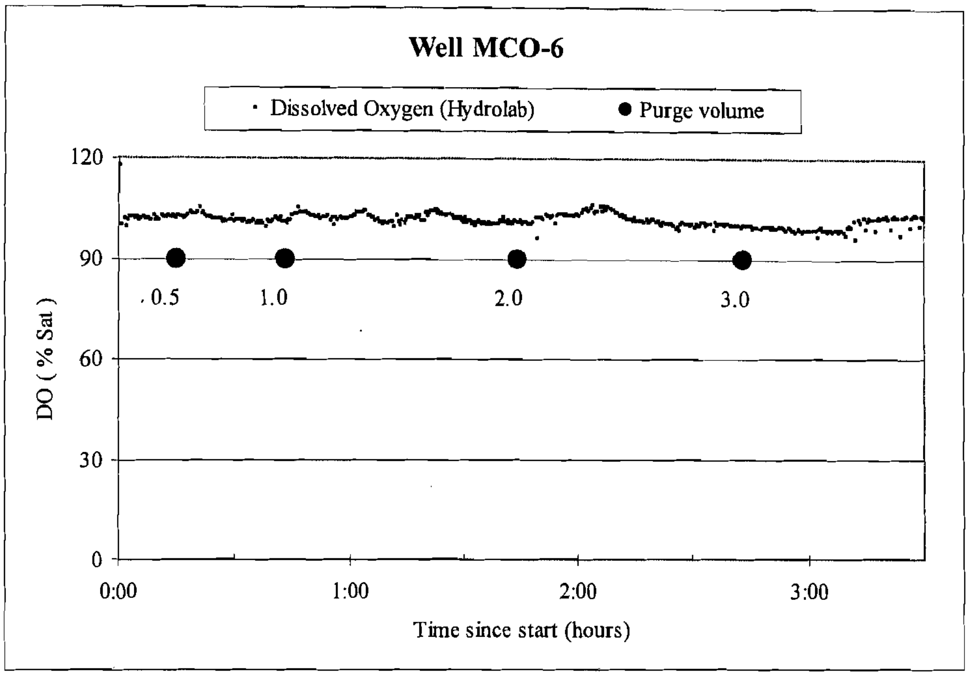

Figure 79. MCO-6 dissolved oxygen results from the Hydrolab. Solid circles indicate the number of well bores purged.

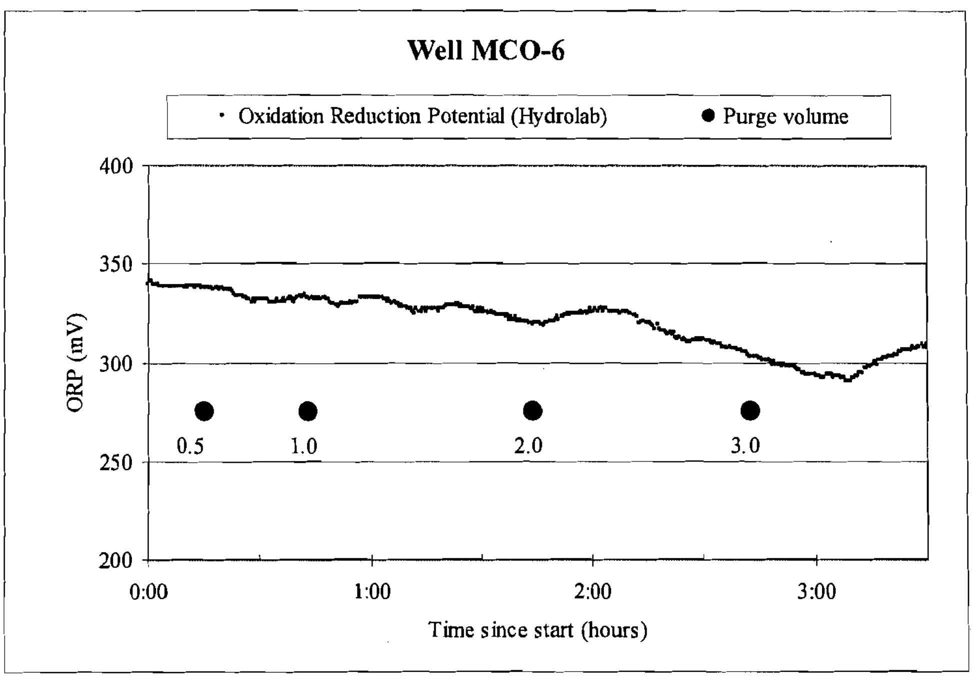

Figure 80. MCO-6 oxidation-reduction potential results from the Hydrolab. Solid circles indicate the number of well bores purged.

The metals analysis for MCO-6 shows the typical decrease in Al and Fe (Figure 81) after one-half well bore purged, with little subsequent change. Fe is not detected after the first sample. Ba, B, Sr, and Mo all showed little change, Zn was near the detection limit (Figure 82). Sulfate, fluoride, chloride and total dissolved solids show little change (Figure 83). Chloride seems to have the greatest percent difference, yet the concentrations change little.

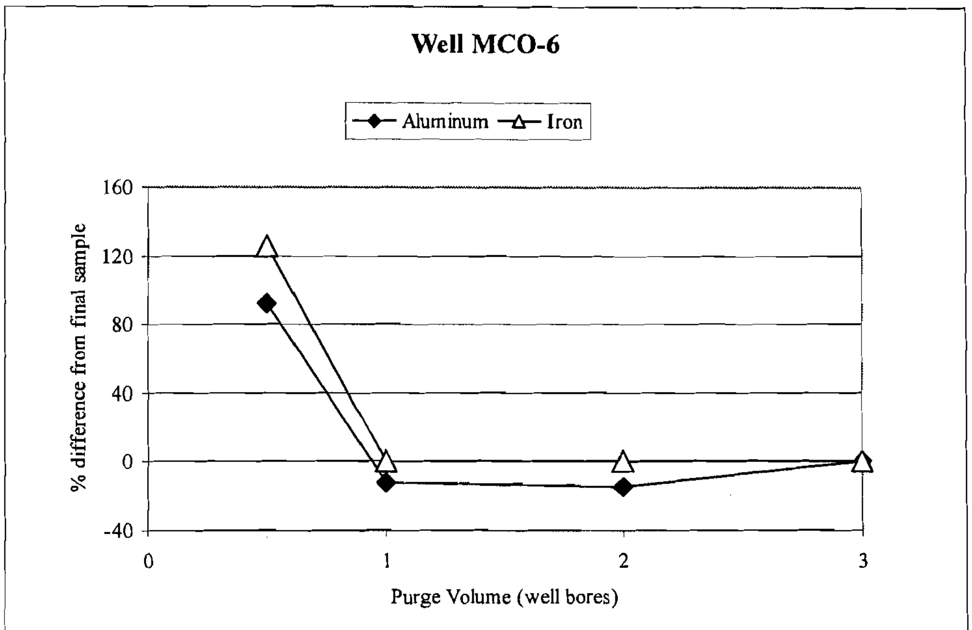

Figure 81. MCO-6 Al and Fe results compared to the final sample Fe drops below the detection limit after one well bore purged.

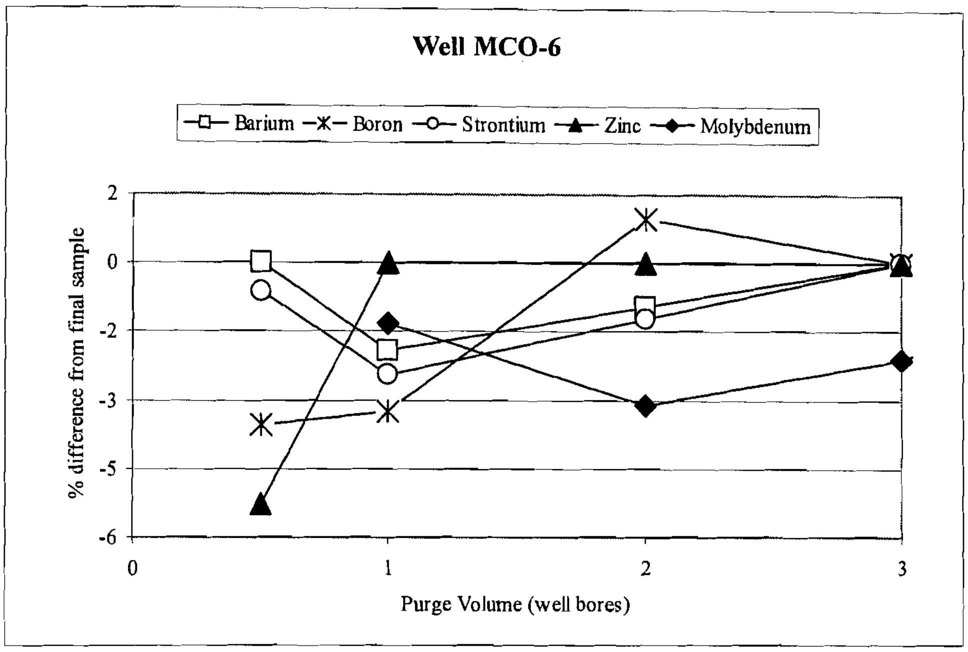

Figure 82. MCO-6 Ba, B, Sr, Zn and Mo results compared to the final sample. Zn was near the detection limit throughout the sampling event.

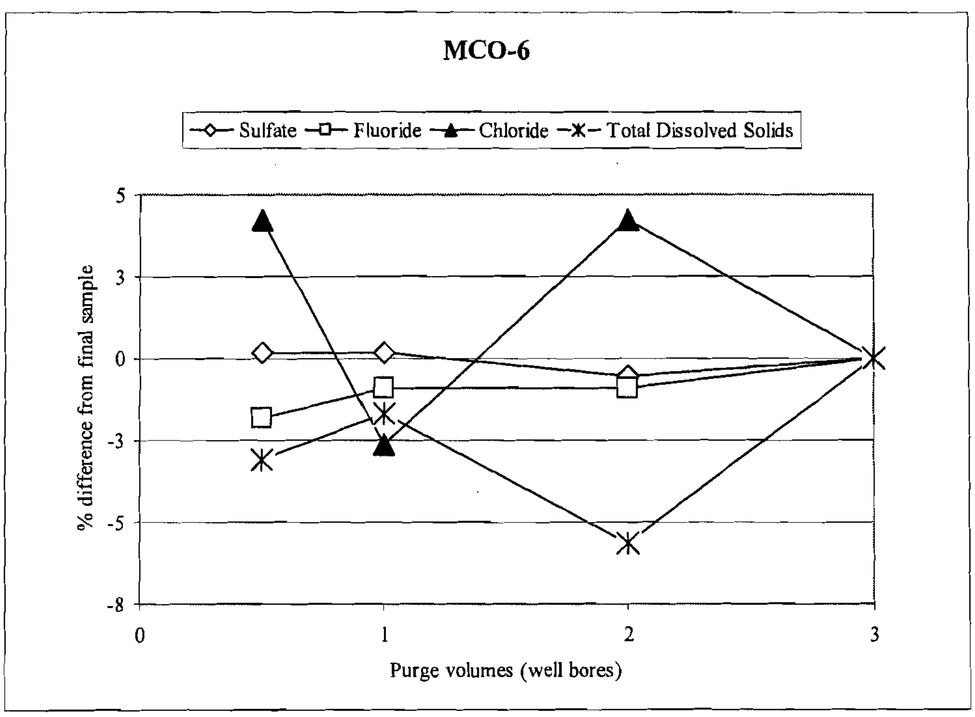

Figure 83. MCO-6 sulfate, fluoride, chloride and total dissolved solids results compared to the final sample.

The concentrations for total phosphorous, and nitrate-nitrite as nitrogen show little change, as the concentrations vary slightly (Figure 84). Total alkalinity does show change: the concentrations were 160 mg/L, 68 mg/L, 80 mg/L, and 165 mg/L. It seems likely that these results are not representative of the formation water. Finally for MCO-6, the results for Ca, K, Mg, Na, and SiO_2 showed little changes (Figure 85).

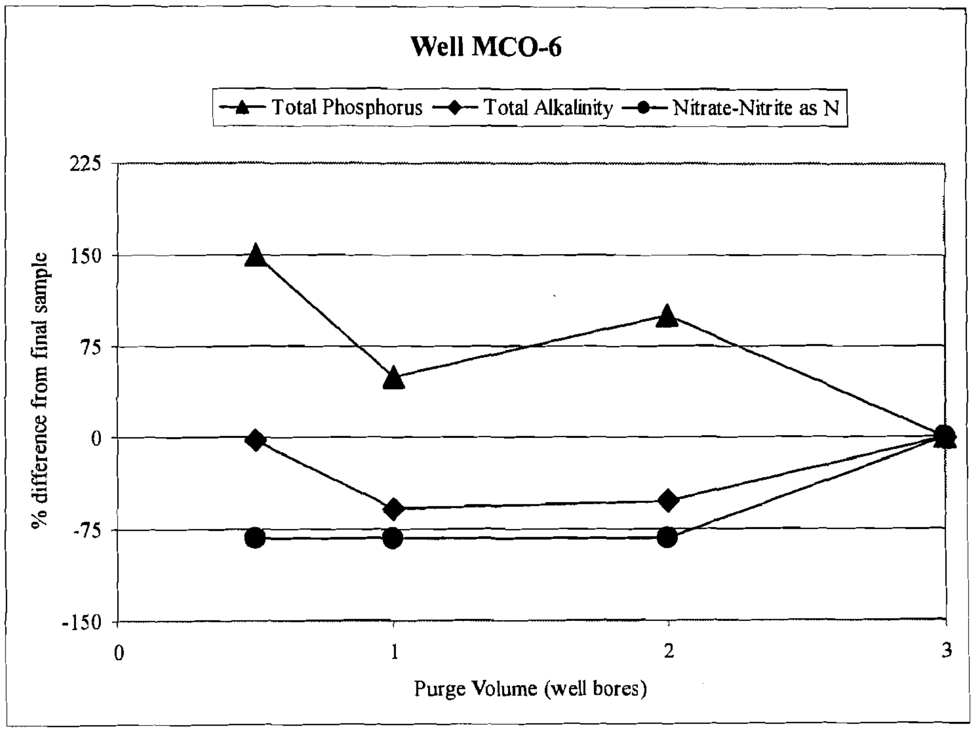

Figure 84. MCO-6 total phosphorous, total alkalinity and nitrate-nitrite as N results compared to the final sample. Concentrations change little.

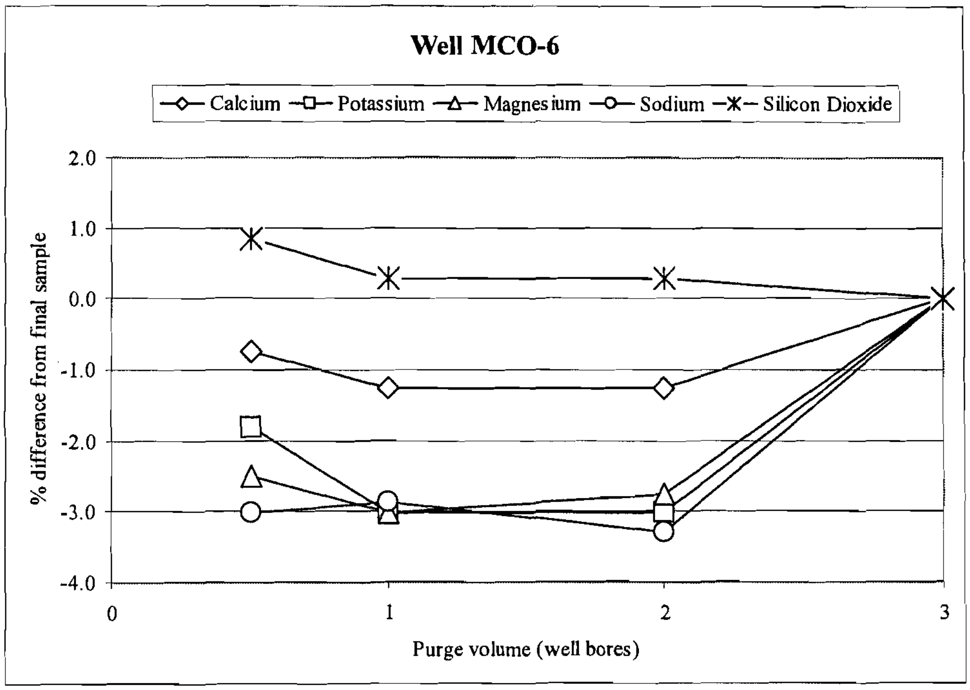

Figure 85. MCO-6 Ca, K, Mg, Na and SiO_2 results compared to the final sample.

MCO-7

For MCO-7, drawdown was approximately 0.85 ft at a purge rate of 0.19 LPM (Figure 86). Once again this is more drawdown than NMED recommends. The results for turbidity at this well were not like the other wells, possibly due to the greater drawdown. Turbidity increased from one-half to two well bores purged, and then dropped back down to its initial level (Figure 87).

The Hydrolab readings for pH stabilized the whole time at approximately 6.9 (Figure 88). The Hydrolab values were slightly lower than the manual values and slowly increased throughout the event. The manual readings for pH did not show stabilization. EC for both the Hydrolab and manual readings stabilized throughout the sample event (Figure 89). The EC readings for both were approximately 500 μS/cm.

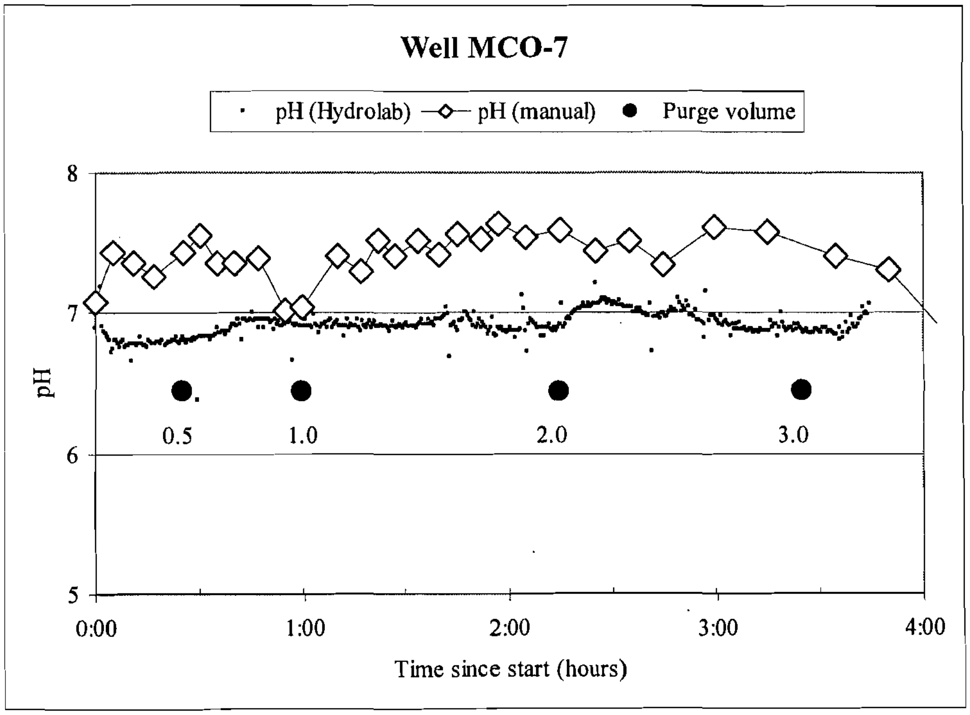

Figure 88. MCO-7 pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

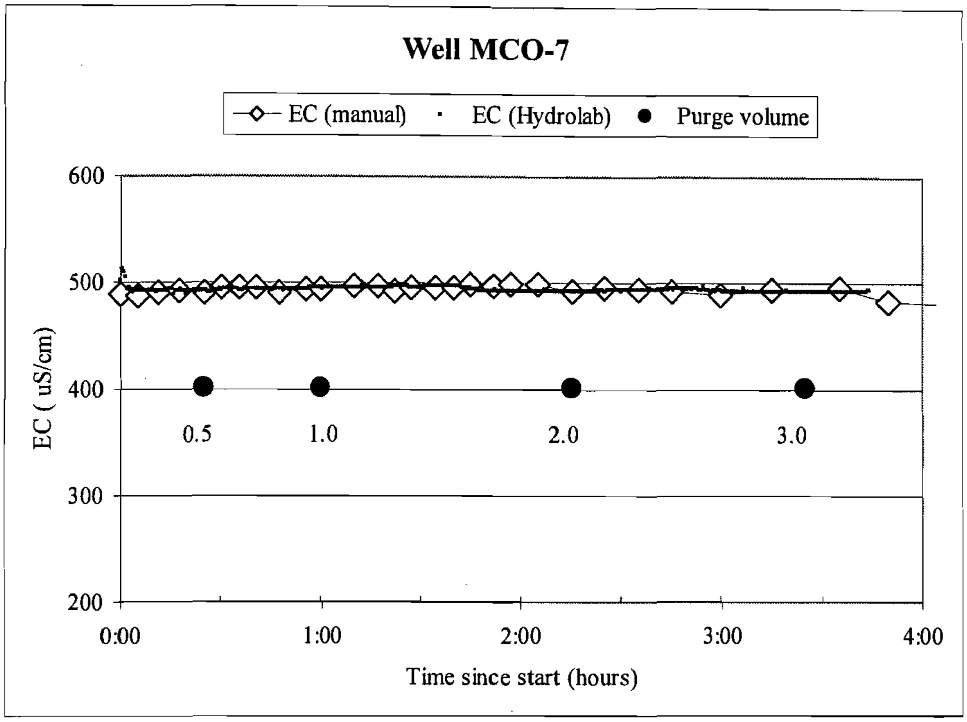

Figure 89. MCO-7 conductance results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

Temperature from the Hydrolab for MCO-6 gradually increased throughout the sampling event, showing no stabilization. The manual readings cycled up and down throughout the event, also showing no stabilization (Figure 90). DO readings for MCO-7 stabilized after one well bore purged at 91 % saturation (Figure 91). From one-half to one well bore purged; the DO probe was having trouble stabilizing, perhaps due to a malfunction. The ORP readings slowly decreased from one-half to one well bore purged, although stable the whole time at around 330 mV (Figure 92).

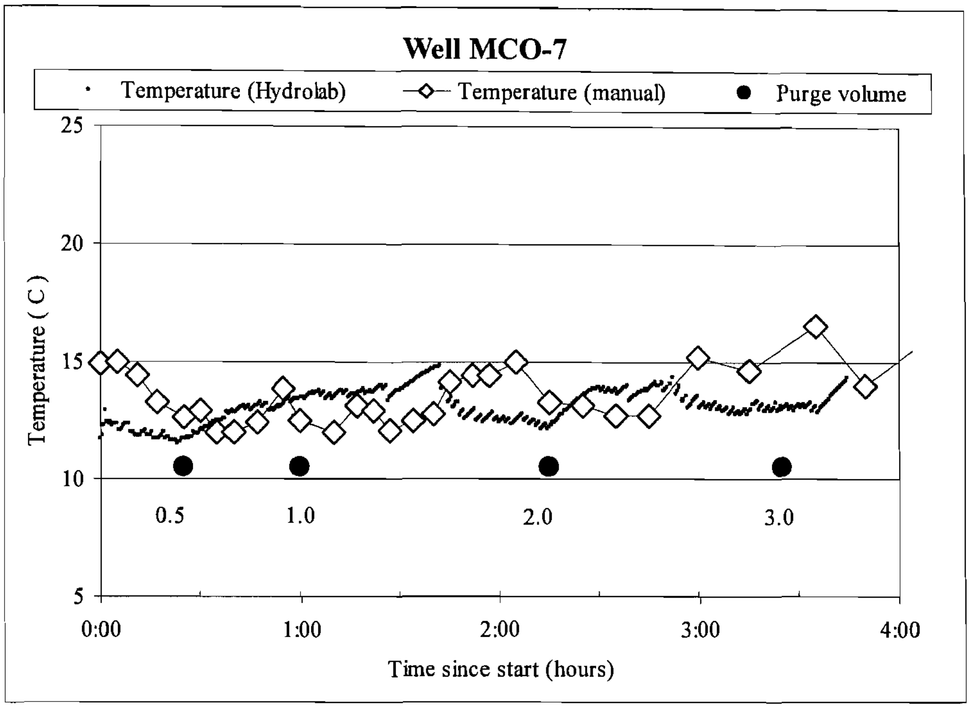

Figure 90. MCO-7 temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

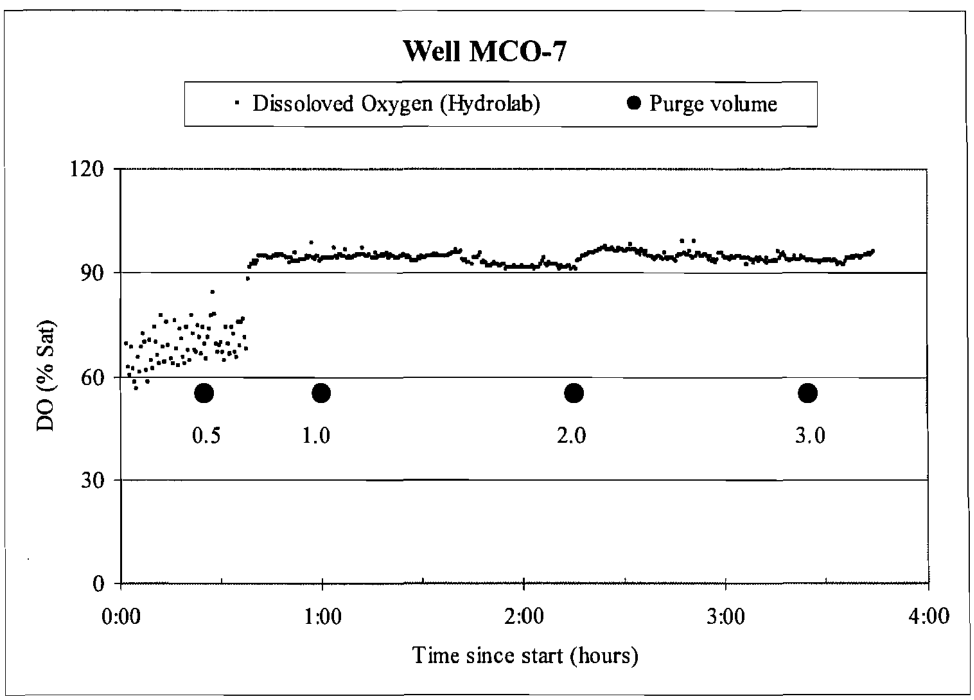

Figure 91. MCO-7 dissolved oxygen results from the Hydrolab. Solid circles indicate the number of well bores purged.

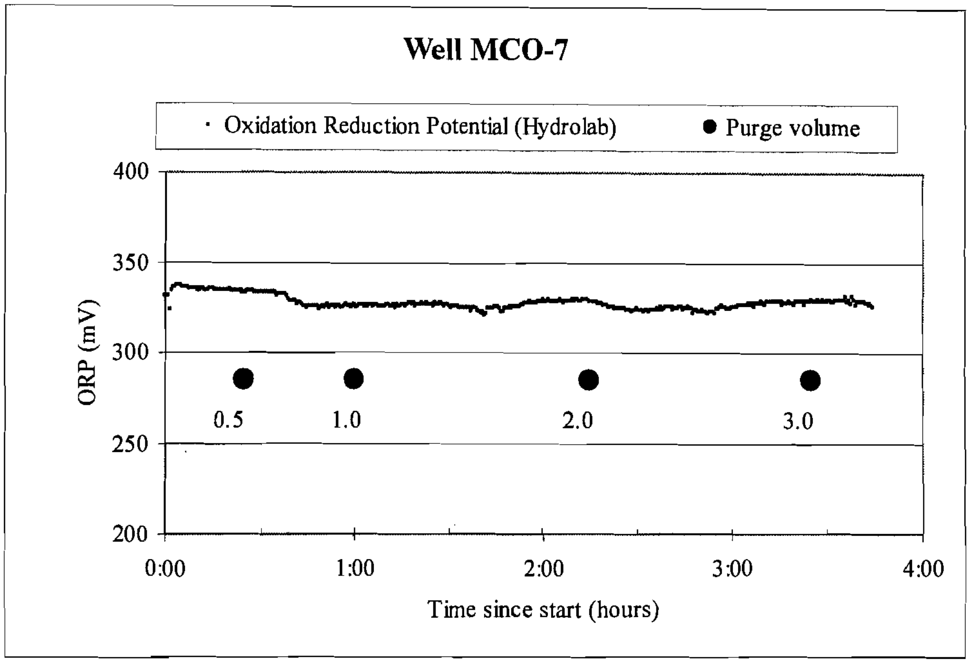

Figure 92. MCO-7 oxidation-reduction potential results from the Hydrolab readings. Solid circles indicate the number of well bores purged.

The metals analysis showed Al, and Fe creating a bell shaped curve similar to the turbidity trend, while Cd decreased after one-half well bore purged (Figure 93). For Cd the change in concentrations is little. The metals Ba, Mo, and Ni showed some variation, while Sr did not change (Figure 94). The changes are small over the sampling event. Al, Fe, and Ba, follow the same trend as the turbidity readings. Once again, B and Zn showed little change until the last sample (Figure 95). I do not have an explanation for this. Sulfate, nitrate-nitrite as nitrogen, fluoride, and chloride all showed little change (Figure 96).

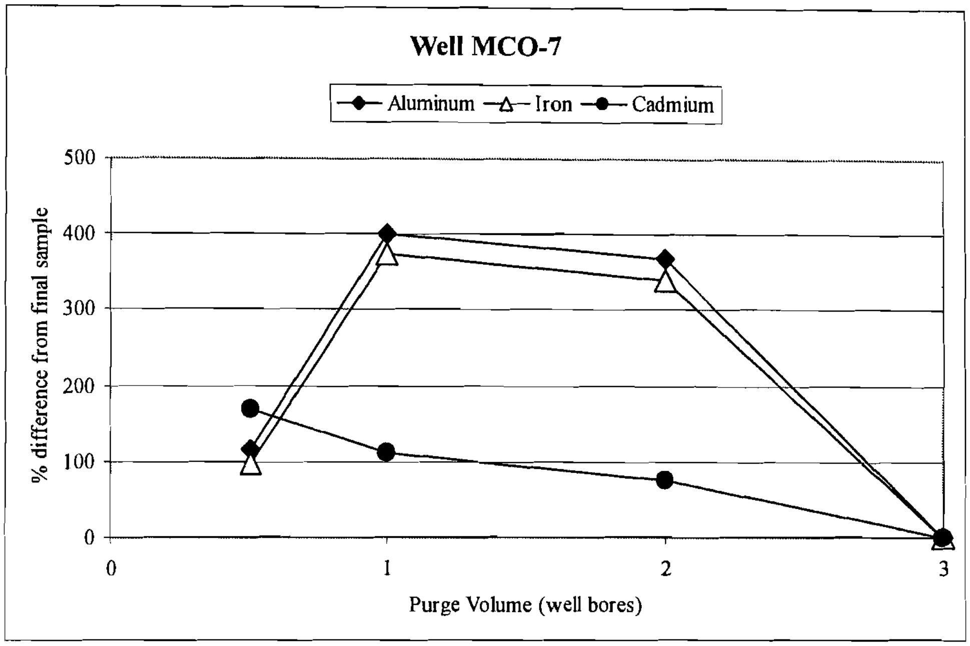

Figure 93. MCO-7 Al, Fe and Cd results compared to the final sample. Note bell shaped curve that Al and Fe exhibit. This is similar to the turbidity plot for MCO-7.

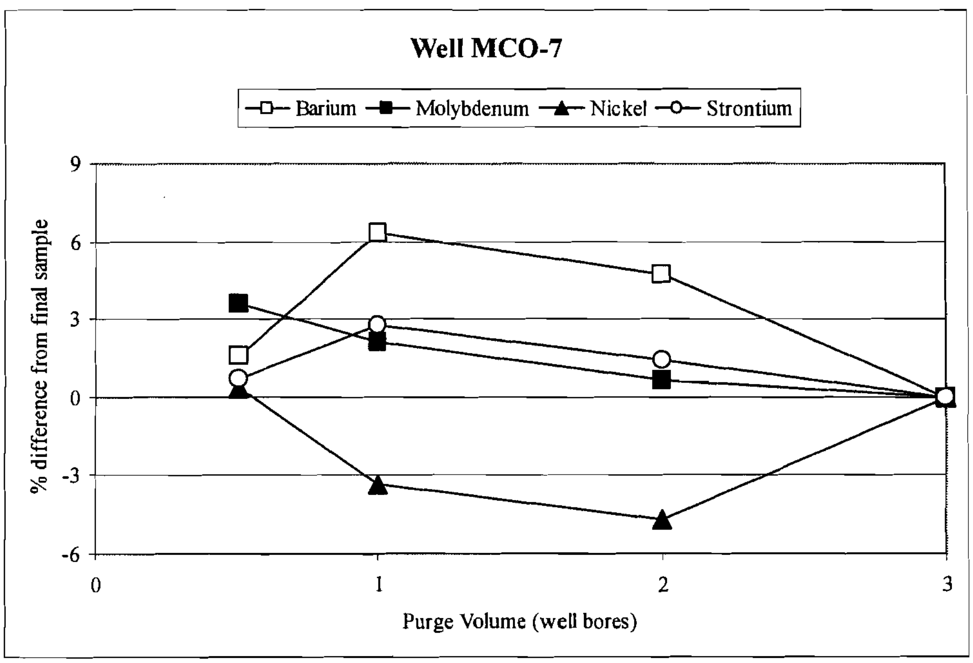

Figure 94. MCO-7 Ba, Mo, Ni and Sr results compared to the final sample.

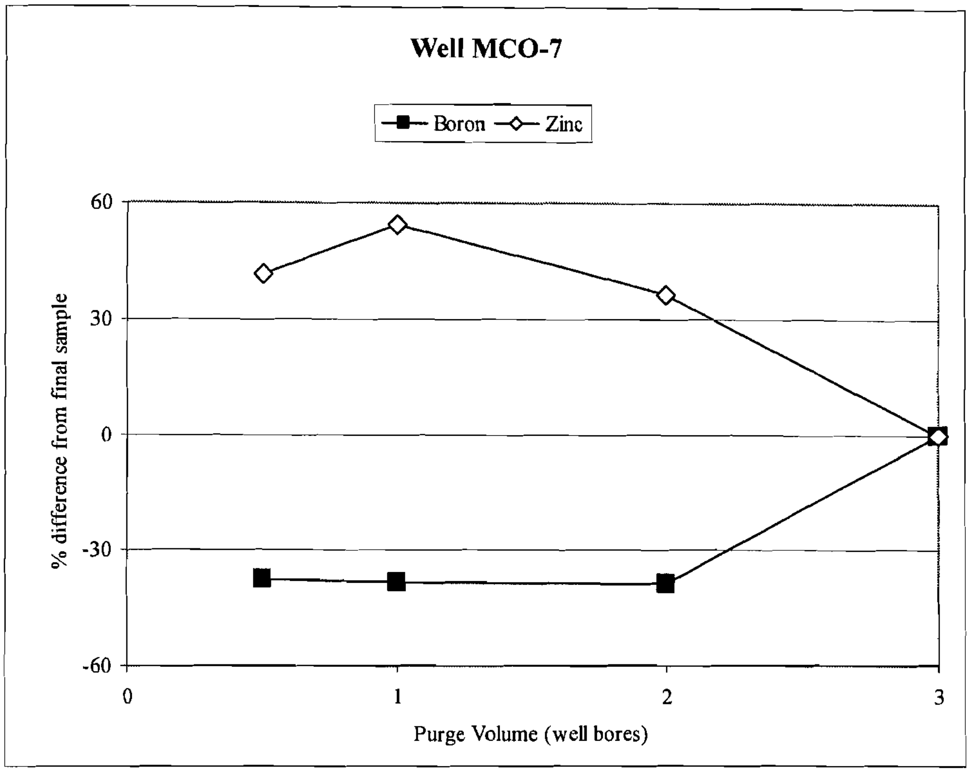

Figure 95. MCO-7 B and Zn results compared to the final sample.

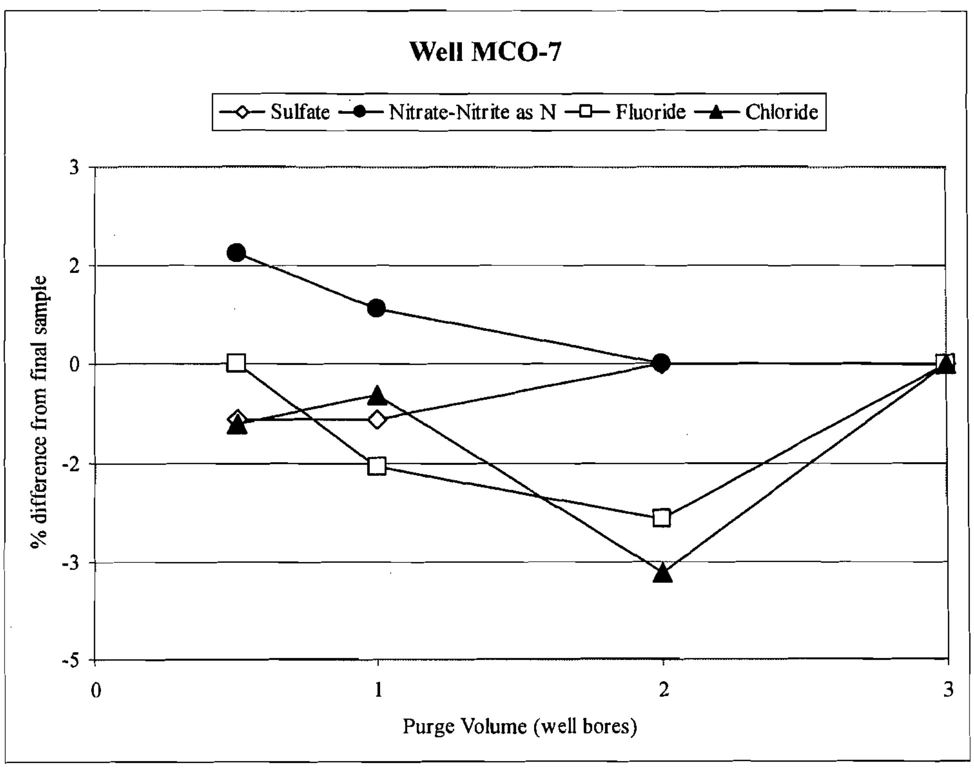

Figure 96. MCO-7 sulfate, nitrate-nitrite as nitrogen, fluoride and chloride results compared to the final sample.

Total alkalinity, total dissolved solids and total phosphorous did show notable variation (Figure 97). Total alkalinity and total dissolved solids both have much lower results for the first samples taken. The concentrations for total alkalinity were 84 mg/l, 108 mg/l, 106 mg/l, and 103 mg/l while the concentrations for total dissolved solids were 201 mg/l, 327 mg/l, 335 mg/l, and 333 mg/l. The analysis for the major cations and anions show little change (Figure 98).

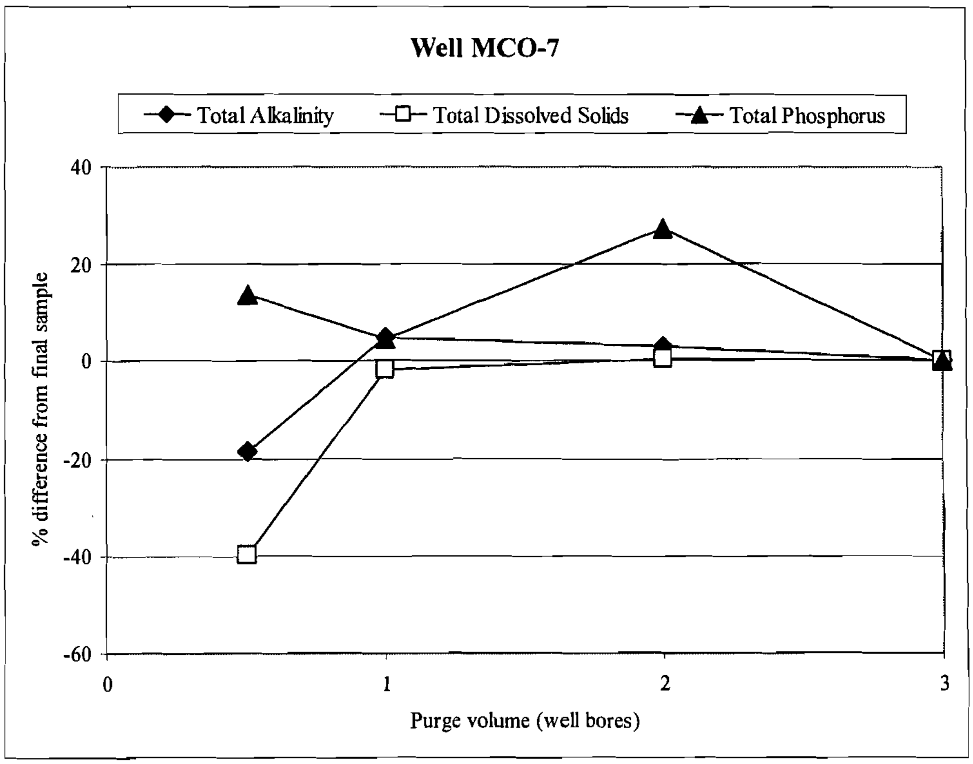

Figure 97. MCO-7 total alkalinity, total dissolved solids and total phosphorous results compared to the final sample.

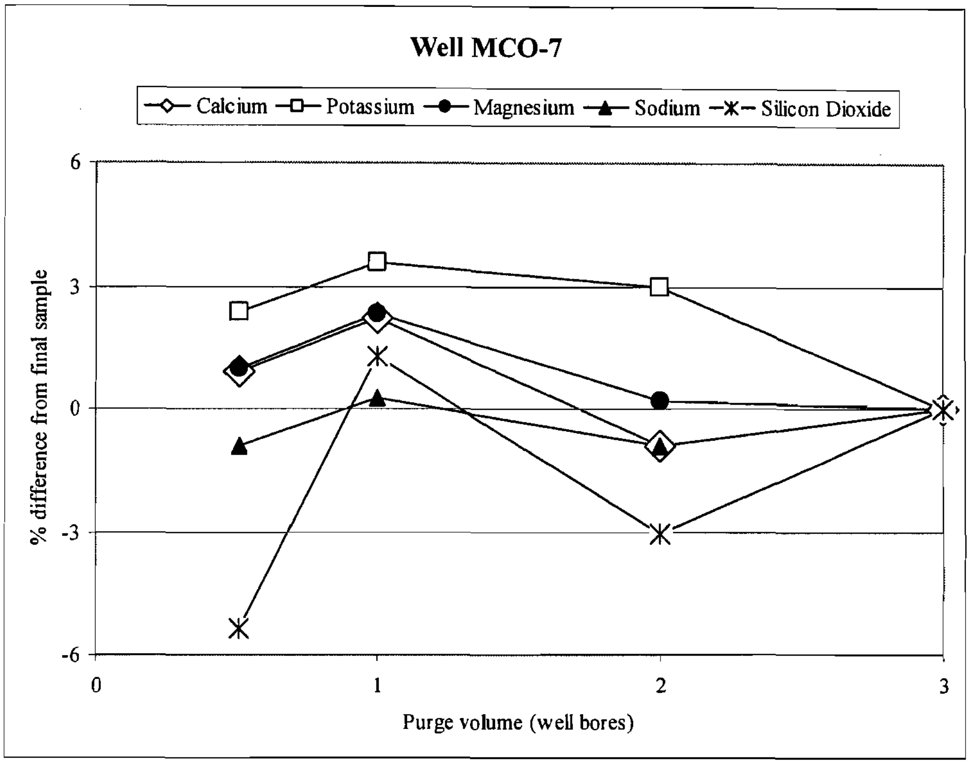

Figure 98. MCO-7 Ca, K, Mg, Na and SiO_2 results compared to the final sample.

Cañada del Buey

CDBO-6

Cañada del Buey was a particularly difficult well with which to work. Historically, turbidity levels are high and there is very little water. Once the sampling event started, we learned the purge rate had to be lowered two times to 0.17 LPM before drawdown stabilized (Figure 99). By the time stabilization had occurred, the well had been drawn down 1.4 ft, which was where the top of the bladder pump was located. In spite of the low purge rate, drawdown was significant and turbidity was high throughout the sampling event.

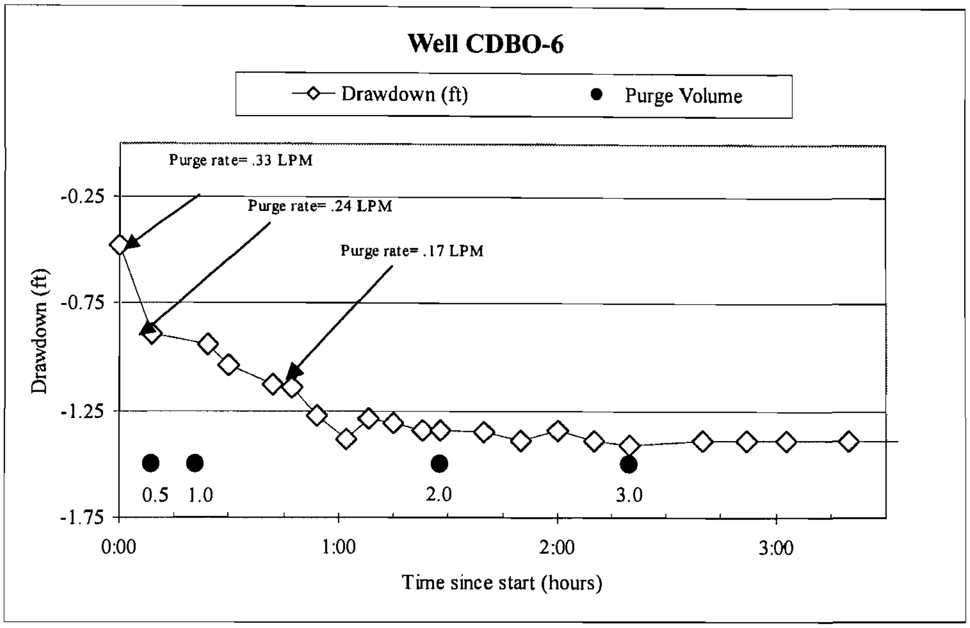

Figure 99. CDBO-6 drawdown. Solid circles indicate the number of well bores purged.

The manual turbidity readings stabilized after two well bores purged at approximately 40 NTU (Figure 100). This drop in turbidity is consistent with the decline in drawdown. No Hydrolab turbidity readings were collected because of the sunlight.

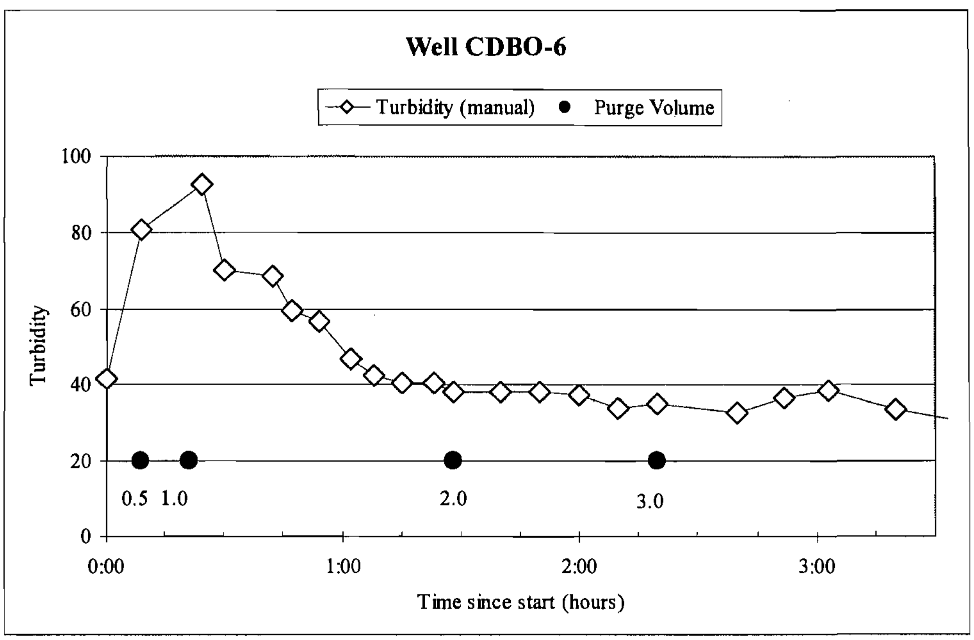

Figure 100. CDBO-6 turbidity results from manual readings. Solid circles indicate the number of well bores purged.

The manual readings for pH stabilized the whole time at approximately 7.1 (Figure 101). The Hydrolab values were slightly lower than the manual values and slowly increased throughout the event but met NMED stabilization criteria. The Hydrolab readings for pH show stabilization at approximately around 6.8. EC for both the Hydrolab and manual readings were stable the whole time (Figure 102). The EC readings for both were approximately 200 μS/cm. Temperature from both the Hydrolab and from the manual readings for CDBO-6 gradually increased throughout the sampling event (Figure 102).

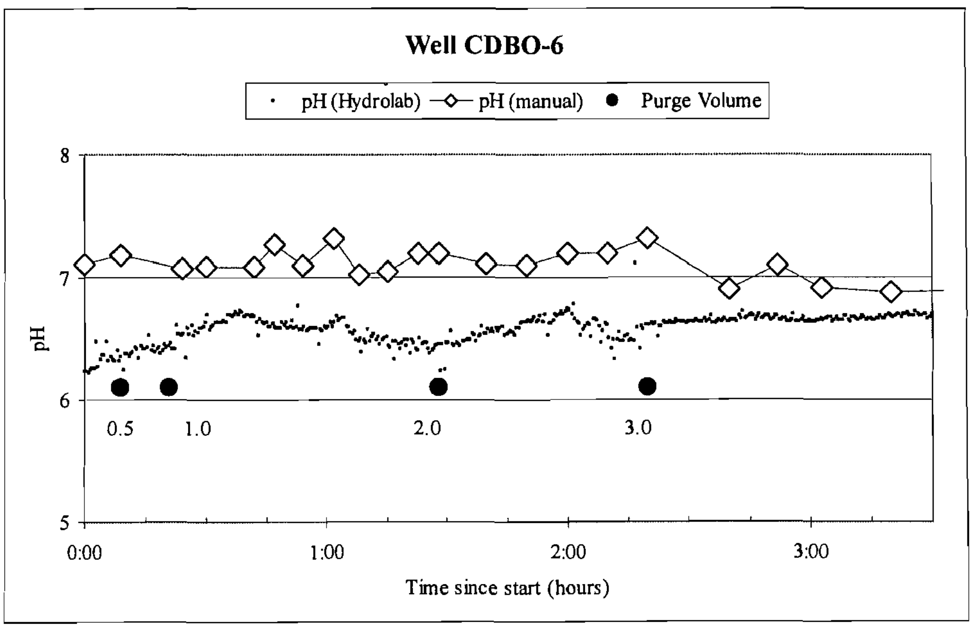

Figure 101. CDBO-6 pH results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

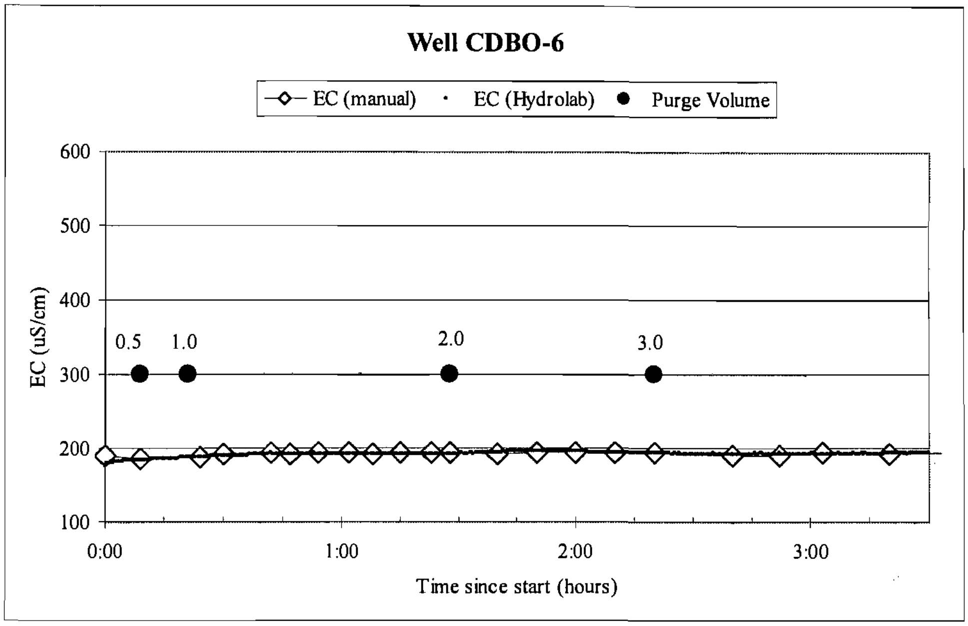

Figure 102. CDBO-6 conductance results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

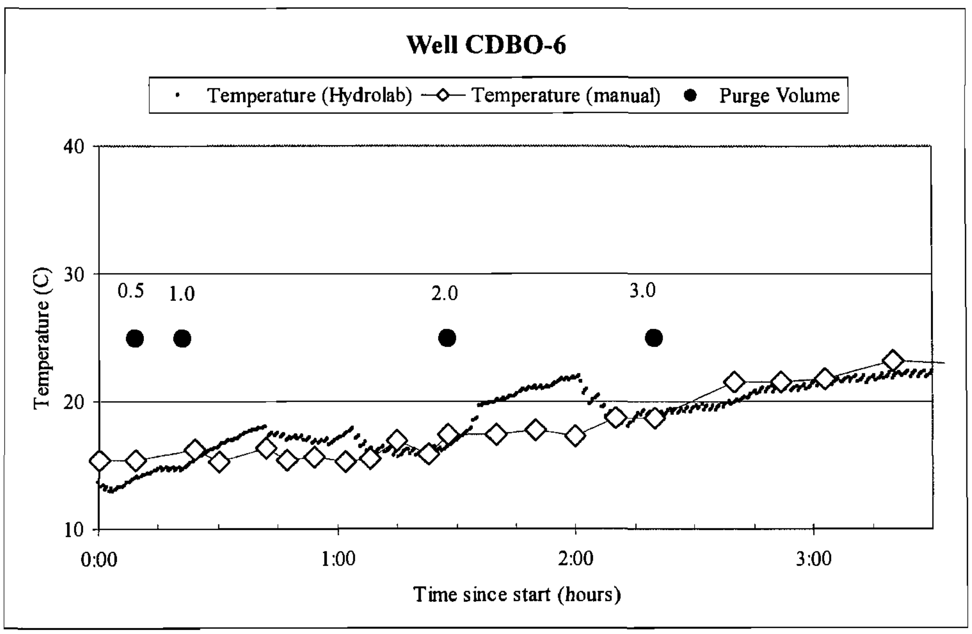

Figure 103. CDBO-6 temperature results from the Hydrolab and manual readings. Solid circles indicate the number of well bores purged.

DO readings for CDBO-6 did not stabilize (Figure 104). The ORP readings slowly decreased from one-half to one well bore purged. Then stabilization was seen the whole time at around 360 mV (Figures 105).

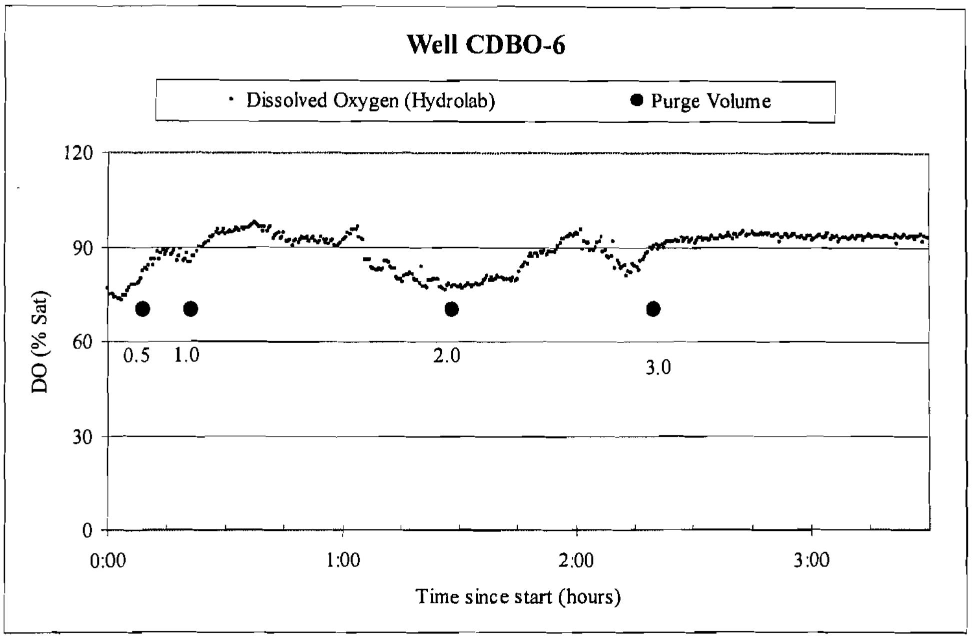

Figure 104. CDBO-6 dissolved oxygen results from the Hydrolab readings. Solid circles indicate the number of well bores purged.

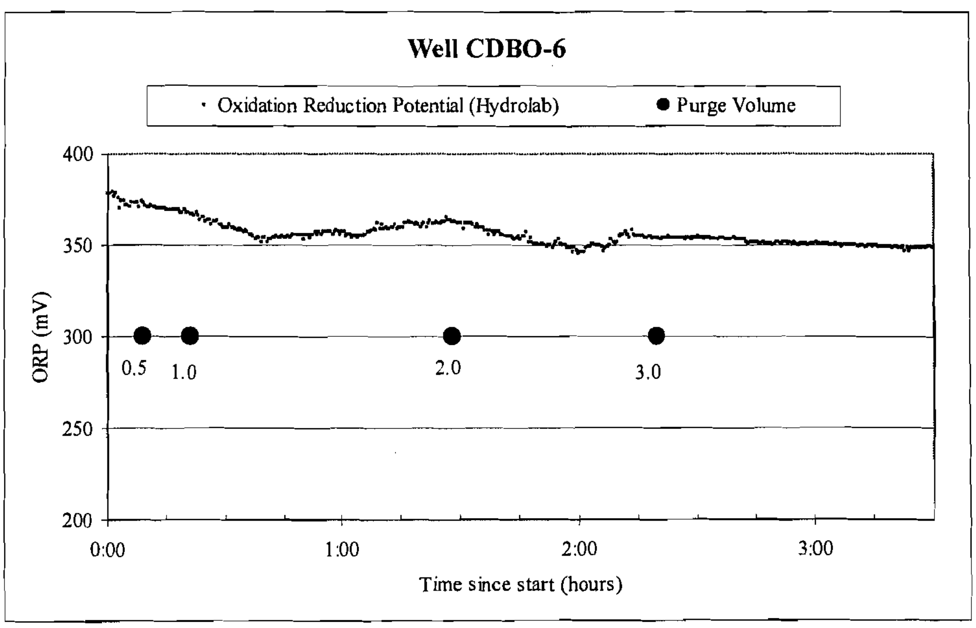

Figure 105. CDBO-6 oxidation-reduction potential results from the Hydrolab readings. Solid circles indicate the number of well bores purged.

The chemistry analysis for CDBO-6 was unlike other wells. In general, all percent differences were larger, and concentrations were higher, particularly for Al and Fe. This might be attributed to the higher turbidity levels and the large decline in drawdown. Figure 106 shows the changes that occurred for Al, Ba, and Fe. Al and Fe exhibit relatively little change from one-half well bore to one well bore purged, with a large overall change after one well bore purged. Ba, on the other hand, increases by approximately 15% after one-half well bore purged.

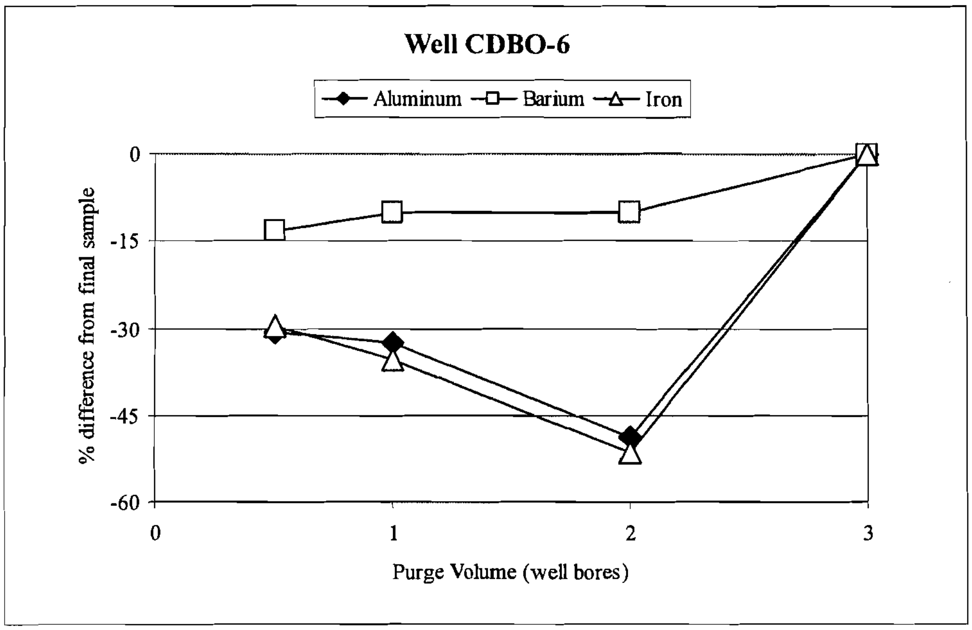

Figure 106. CDBO-6 Al, Fe and Ba results compared to the final sample.

The changes for Co, Mn and Sr are shown in Figure 107. Sr exhibits little change after one-half well bore purged. On the other hand, Co and Mn exhibited the largest changes for these analytes seen in this study. When looking at concentration values for Co, the samples taken at one-half well bore and two well bores purged are below the detection limit 0.541 μg/l. For the samples taken at one and three well bores, the concentrations were 7.09μg/l and 6.39μg/l. Mn does show some change after one-half well bore purged.

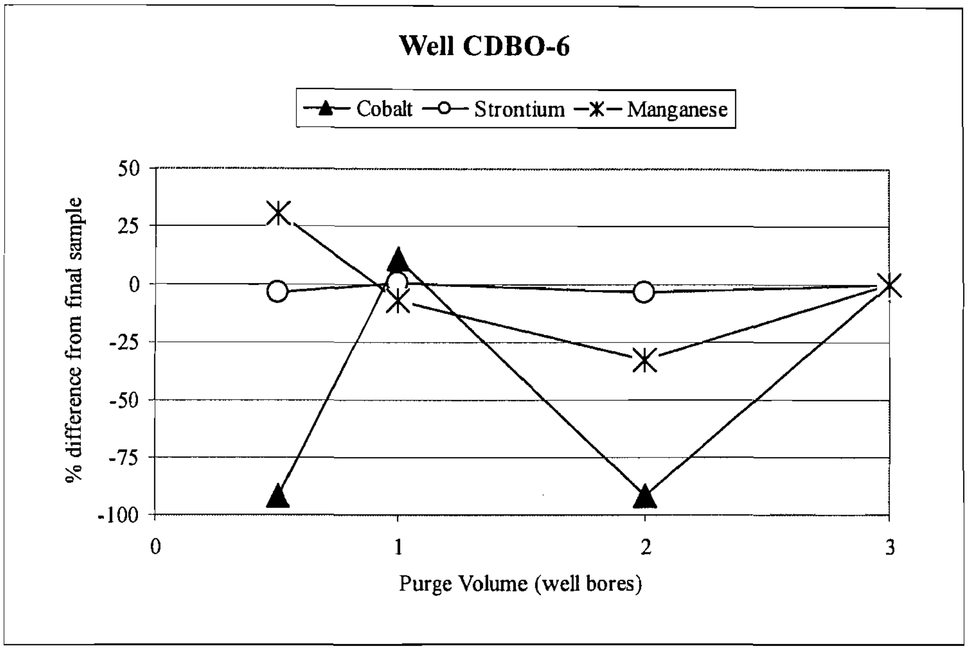

Figure 107. CDBO-6 Co, Sr and Mn results compared to the final sample.

V and Zn show change after one well bore purged, while Pb was very close to the detection limit of 1.51 μg/L for samples taken at one-half, one, and three well bores, and undetected in the sample taken at the second well bore purged (Figure 108).

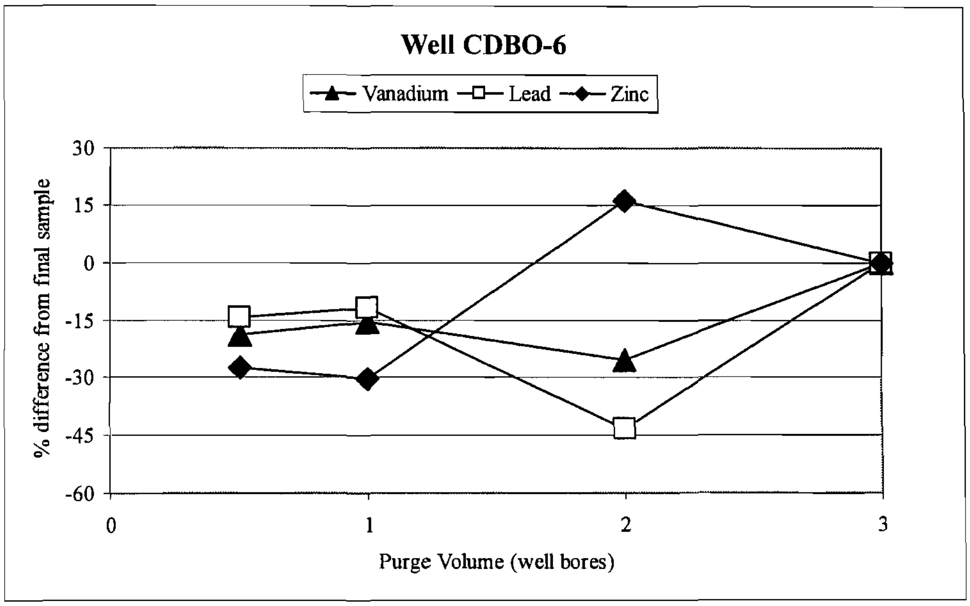

Figure 108. CDBO-6 V, Pb and Zn results compared to the final sample.

Total alkalinity, total dissolved solids, and total phosphorous show little change after one-half well bore purged (Figure 109). The analysis for the other major cations and anions, with the exception of silica, show there were little changes after one-half well bore purged (Figures 110 and 111). Silica, on the other hand, showed the largest decrease of any location.

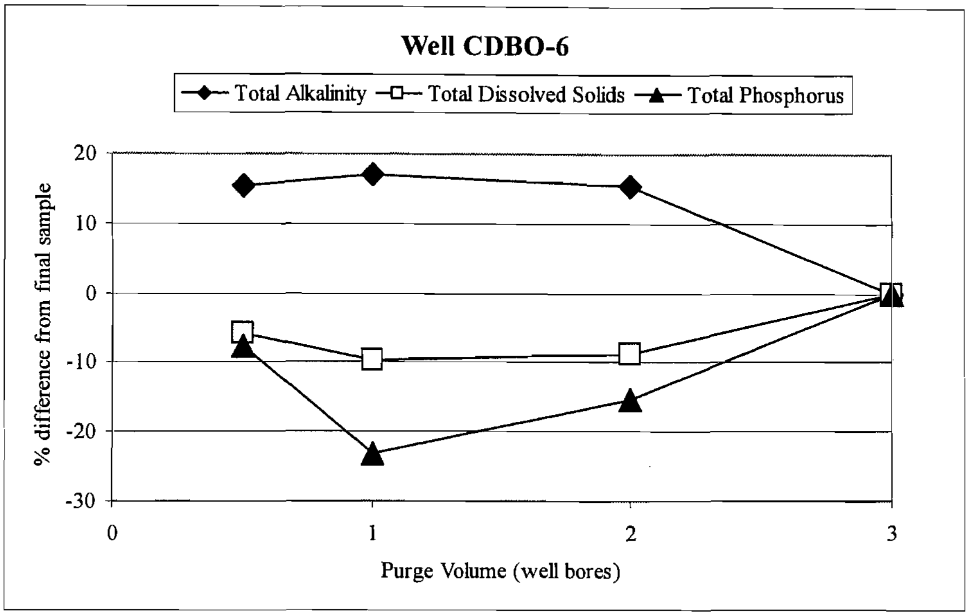

Figure 109. CDBO-6 total alkalinity, total dissolved solids and total phosphorous results compared to the final sample.

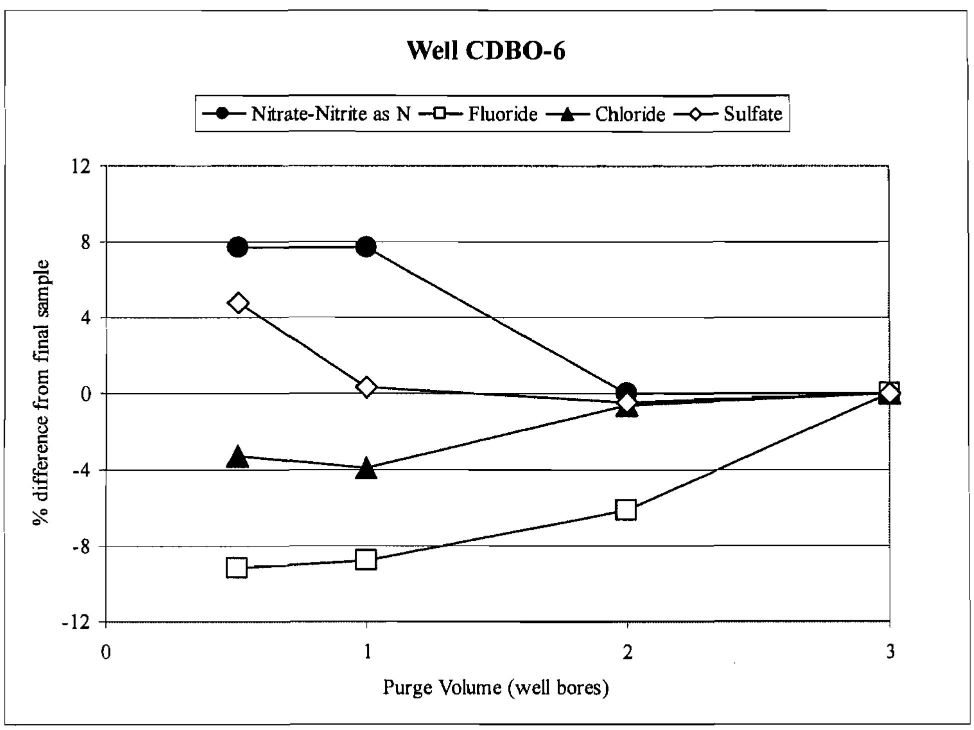

Figure 110. CDBO-6 sulfate, nitrate-nitrite as nitrogen, fluoride and chloride results compared to the final sample.

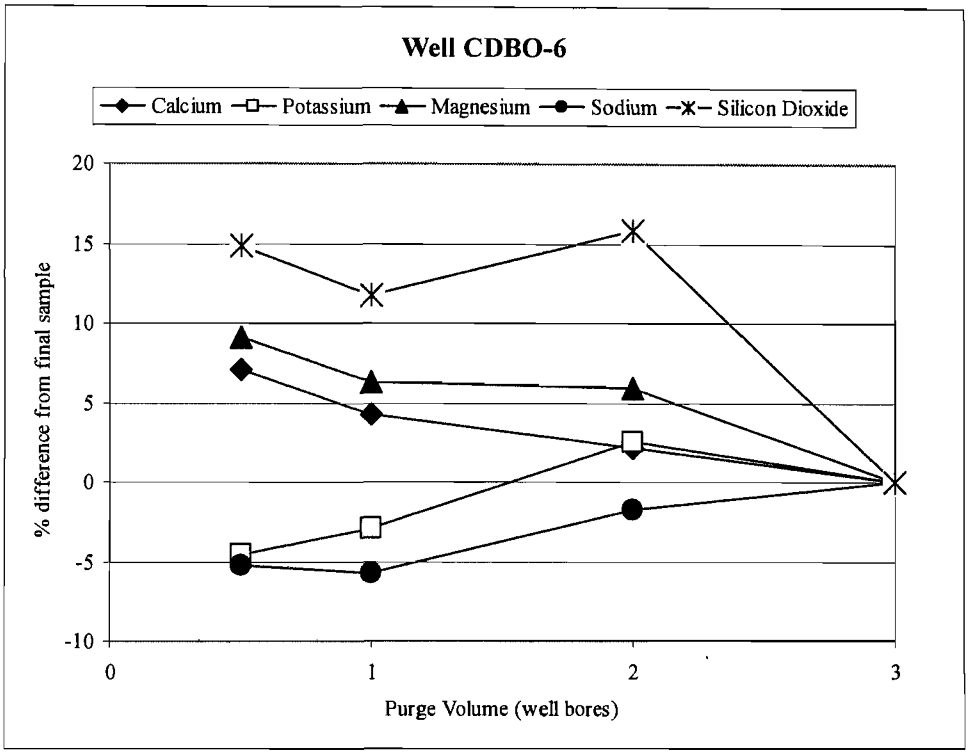

Figure 111. CDBO-6 Ca, K, Mg, Na and SiO_2 results compared to the final sample.

Conclusion

This study was conducted to determine how water quality varies during purging of shallow alluvial wells. While using the low-flow technique, we established a trend of water quality parameters and chemistry results for each of the wells sampled. These results show drawdown had the greatest effect on turbidity and turbidity has the greatest effect on sample quality. This result suggests a representative sample can generally be collected after one well bore of water purged for wells that have minimal drawdown (< 0.1 ft) and low (< 5 NTU), stable turbidity.

Four of the seven wells had drawdown in excess of 0.3 ft, which corresponds to increased turbidity readings and lack of stabilization. LAO-0.7 and MCO-5 had similar measurements of drawdown (around 0.5 ft), yet still had low turbidity readings (<5 NTU), that did not stabilize based on NMED criteria. The other two wells, MCO-7 and CDBO-6 had much greater drawdown, up to 1.40 ft. In these cases, turbidity values were very high, (>20 NTU) and did not stabilize. At the other three wells, (LAO-C, MCO-6, LAO-3A) drawdown was below 0.3 ft and turbidity was below 5 NTU, and stable.

The only significant changes in chemistry were among the metals, in particular Al and Fe. The largest changes occurred from one-half well bore to one well bore purged; after one well bore purged there were generally little subsequent changes. The trend seen in chemistry results for Al and Fe generally followed the trend for turbidity in five of the seven wells. This similarity was probably due to Al and Fe being constituents of suspended sediments. The exceptions were MCO-5 and CDBO-6; MCO-5 showed the typical decrease in Al and Fe, but not turbidity. CDBO-6 showed no large decrease in Al and Fe, or any similarity of the trends between Al, Fe, and turbidity. The major cation and anion results did not show any large changes during purging. In part, this lack of change occurred because the major cations and anions were filtered and were not affected by turbidity.

We were not able to measure representative DO, ORP, or temperature due to limitations in the sample setup. For DO and ORP we were unable to keep air out of the sampling setup. For temperature, water brought to the surface and allowed to warm in an instrument, or collected in a cup to be measured, is not representative of the formation. We collected consistent and stable manual readings for turbidity; and collected pH and EC consistently with both the Hydrolab and manually. The readings from the Hydrolab, with the exception of pH and EC, were not representative of the alluvial groundwater because of limitations in the sampling setup.

For this study, the Hydrolab was not very useful because of the inability to observe the history of the readings while being collected. In order to make decisions regarding stabilization of the field parameters, you need to be able to see the time series. With the Hydrolab, all you see is the readings at that point in time. Only when the data are downloaded and transferred into a spreadsheet can you see the data trends. The Hydrolab also requires considerable knowledge to use, in conjunction with a laptop computer. The last issue related to the Hydrolab was the sensitivity of the turbidity probe to light. If the entire unit were not completely covered (not just shaded) the probe would not work. The use of a flow-through type system would be good to enable you to collect DO on site, but to determine the best way to accomplish this will take more thought and investigation.

In conclusion, this paper describes two important concepts for sampling these seven shallow alluvial wells. The first concept relates to drawdown, and how drawdown affects turbidity. The second concept is that turbidity is the main field parameter that affected the concentration of various unfiltered metals, in this case, Al and Fe. In this study we observed that greater the drawdown, increased turbidity.

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Appendix- Chemistry Data

Location	Date Sampled
LAO-C	4/23/02

Metals Analysis		0.5		1		2		3	
Analyte Desc	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Std Uom
Silver	<	0.197	<	0.197	<	0.197	<	0.197	ug/L
Aluminum		567		423		272		62.2	ug/L
Arsenic	<	4.57		4.57	<	4.57	<	4.57	ug/L
Boron	<	27.4	<	18	<	31	<	33.6	ug/L
Barium		76.6		72.3		71.3		70.6	ug/L
Beryllium	<	0.203	<	0.203	<	0.203	<	0.203	ug/L
Cobalt	<	0.295	<	0.295	<	0.295	<	0.295	ug/L
Chromium	<	0.781	<	0.781	<	0.781	<	0.781	ug/L
Copper	<	3.85	<	2.99	<	2.72	<	2.67	ug/L
Manganese		148		55.6		22.6	<	6.82	ug/L
Molybdenum	<	3.06	<	3.24	<	3.05	<	3.82	ug/L
Nickel	<	2.08	<	0.871	<	1.2	<	1.25	ug/L
Selenium	<	3.09	<	3.09	<	3.09	<	3.09	ug/L
Tin	<	2.4	<	2.4	<	2.4	<	2.4	ug/L
Strontium		133		133		135		137	ug/L
Vanadium	<	1.9	<	1.53	<	1.46	<	1.26	ug/L
Zinc		6.73		5.84	<	3.59	<	4.55	ug/L
Iron		328		224		133	<	38.9	ug/L
Cadmium	<	0.109	<	0.05	<	0.05	<	0.05	ug/L
Lead	<	0.683	<	0.412	<	0.351	<	0.261	ug/L
Antimony	<	0.212	<	0.135	<	0.287	<	0.316	ug/L
Thallium	<	0.067	<	0.045	<	0.025	<	0.021	ug/L

Metals Analysis				
Percent difference from 3rd well casing volume				
	0.5	1	2	3
Aluminum	811.58	580.06	337.30	0.00
Iron	743.19	475.84	241.90	0.00
Barium	8.50	2.41	0.99	0.00
Manganese	2070.09	715.25	231.38	0.00
Strontium	-2.92	-2.92	-1.46	0.00
Zinc	76.18	52.88	0.00	0.00

General Inorganics		0.5		1		2		3	
Analyte Desc	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Std Uom
Total Phosphorus		0.07		0.07		0.03		0.04	mg/L
Total Dissolved Solids		273		271		273		272	mg/L
Carbonate alkalinity	<	1.45	<	1.45	<	1.45	<	1.45	mg/L
Total Alkalinity		90.5		101		75.4		279	mg/L
Bicarbonate Alkalinity		90.2		100		75.1		279	mg/L
Specific Conductance		423		420		419		407	uS/cm
Nitrate-Nitrite as N		0.02		0.02		0.02		0.07	mg/L
Fluoride		0.096		0.153		0.155		0.182	mg/L
Chloride		76.9		77.4		77		77.2	mg/L
Sulfate		11.6		11.6		11.7		11.6	mg/L
Calcium		21.4		21.4		21.2		21.8	mg/L
Potassium		4.36		4.42		4.4		4.46	mg/L
Magnesium		4.67		4.69		4.64		4.76	mg/L
Sodium		57.9		58.3		57		62.5	mg/L
Silicon Dioxide		32.5		32.3		32		34.1	mg/L

General Inorganics				
Percent difference from 3rd well casing volume				
	0.5	1	2	3
Total Phosphorus	75.00	75.00	-25.00	0.00
Total Dissolved Solids	0.37	-0.37	0.37	0.00
Carbonate alkalinity	0.00	0.00	0.00	0.00
Total Alkalinity	-67.56	-63.80	-72.97	0.00
Bicarbonate Alkalinity	-67.67	-64.16	-73.08	0.00
Nitrate-Nitrite as N	-71.43	-71.43	-71.43	0.00
Fluoride	-47.25	-15.93	-14.84	0.00
Chloride	-0.39	0.26	-0.26	0.00
Sulfate	0.00	0.00	0.86	0.00
Calcium	-1.83	-1.83	-2.75	0.00
Potassium	-2.24	-0.90	-1.35	0.00
Magnesium	-1.89	-1.47	-2.52	0.00
Sodium	-7.36	-6.72	-8.80	0.00
Silicon Dioxide	-4.69	-5.28	-6.16	0.00

*< indicates below detection limit

Location	Date
LAO-C	6/4/02

Metals Analysis		0.5		1		2		3		
Analyte	**Symbol**	**Result**	**Symbol**	**Result**	**Symbol**	**Result**	**Symbol**	**Result**	**MDL**	**Units**
Silver	<	0.835	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		374		304		260		256	14.7	ug/L
Arsenic	<	2.24	<	2.24	<	2.24	<	2.24	2.24	ug/L
Boron	<	33.2	<	31	<	16.8	<	19.5	33.2	ug/L
Barium		85.2		83.6		83.2		81.4	0.222	ug/L
Beryllium	<	0.158	<	0.158	<	0.158	<	0.158	0.158	ug/L
Cobalt	<	0.863	<	0.541	<	1.57	<	0.541	0.863	ug/L
Chromium		7.09	<	0.503	<	0.503	<	0.503	0.503	ug/L
Copper	<	1.45	<	1.39	<	1.39	<	1.39	1.45	ug/L
Iron		227		126		109		109	12.6	ug/L
Manganese		102		22.9		13.6	<	8.73	0.296	ug/L
Molybdenum	<	2.4	<	2.11	<	2.02	<	2.27	2.4	ug/L
Nickel	<	4.52	<	1.08	<	0.69	<	0.69	4.52	ug/L
Selenium	<	2.81	<	2.81	<	2.93	<	2.81	2.93	ug/L
Tin	<	0.28	<	0.28	<	0.28	<	0.28	0.28	ug/L
Strontium		150		153		153		151	0.178	ug/L
Vanadium	<	1.94	<	1.92	<	1.68	<	1.9	1.94	ug/L
Zinc	<	3.49	<	2.8	<	1.79	<	1.75	3.49	ug/L
Cadmium	<	0.04	<	0.04	<	0.04	<	0.04	0.04	ug/L
Lead	<	0.37	<	0.256	<	0.196	<	0.197	0.37	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.037	<	0.042	<	0.039	<	0.036	0.042	ug/L

Metals Analysis

Percent difference from 3rd well casing volume

	0.5	1	2	3
Aluminum	46.09	18.75	1.56	0.00
Barium	4.67	2.21	2.21	0.00
Chromium	1309.54	<0.00	<0.00	0.00
Iron	108.26	15.60	0.00	0.00
Manganese	1068.38	162.31	55.78	0.00
Strontium	-0.66	1.32	1.32	0.00

General Inorganics		0.5		1		2		3		
Analyte	**Symbol**	**Std Result**	**Symbol**	**Std Result**	**Symbol**	**Std Result**	**Symbol**	**Std Result**	**MDL**	**Uom**
Total Phosphorus		0.03		0.04		0.04		0.03	0.011	mg/L
Total Dissolved Solids		309		316		307		308	3.07	mg/L
Specific Conductance		417		421		420		422		
Carbonate alkalinity	<	0.725	<	0.725	<	0.725	<	0.725	0.725	mg/L
Total Alkalinity		69.6		72		67.2		64.8	0.725	mg/L
Bicarbonate Alkalinity		69.4		71.8		67		64.6	0.725	mg/L
Nitrate-Nitrite as N		0.02		0.01		0.02		0.01	0.01	mg/L
Chloride		85.6		86.9		86.1		85.7	0.322	mg/L
Fluoride		0.168		0.179		0.21		0.176	0.0553	mg/L
Sulfate		9.97		9.99		10.1		9.91	0.193	mg/L
Calcium		24.3		24.2		24.4		24.1	5.54	mg/L
Potassium		5.36		5.45		5.44		5.53	16.5	mg/L
Magnesium		5.22		5.19		5.21		5.18	5.18	mg/L
Sodium		75		74.6		75.4		74.5	14.4	mg/L
Silicon Dioxide		37.6		37.3		37.2		37.1	0.0212	mg/L

General Inorganics

Percent difference from 3rd well casing volume

	0.5	1	2	3
Total Phosphorus	0.00	33.33	33.33	0.00
Total Dissolved Solids	0.32	2.60	-0.32	0.00
Specific Conductance	-1.18	-0.24	-0.47	0.00
Total Alkalinity	7.41	11.11	3.70	0.00
Bicarbonate Alkalinity	7.43	11.15	3.72	0.00
Nitrate-Nitrite as N	100.00	0.00	100.00	0.00
Chloride	-0.12	1.40	0.47	0.00
Fluoride	-4.55	1.70	19.32	0.00
Sulfate	0.61	0.81	1.92	0.00
Calcium	0.83	0.41	1.24	0.00
Potassium	-3.07	-1.45	-1.63	0.00
Magnesium	0.77	0.19	0.58	0.00
Sodium	0.67	0.13	1.21	0.00
Silicon Dioxide	1.35	0.54	0.27	0.00

< indicates below detection limit

Location	Date sampled
LAO-0.7	6/4/02

Metals Analysis		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Silver	<	0.955	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		491		316		250		240	14.7	ug/L
Arsenic	<	2.24	<	2.24	<	2.24	<	2.24	2.24	ug/L
Boron	<	25.8	<	29.3	<	27.7	<	25	29.3	ug/L
Barium		84.6		83.1		79		77.4	0.222	ug/L
Beryllium	<	0.158	<	0.158	<	0.158	<	0.158	0.158	ug/L
Cobalt	<	3.1	<	4.22	<	2.21	<	2.51	4.22	ug/L
Chromium	<	0.829	<	0.682	<	0.503	<	0.503	0.829	ug/L
Copper	<	1.39	<	1.39	<	1.39	<	1.39	1.39	ug/L
Iron		232		143		107		110	12.6	ug/L
Manganese		984		880		755		709	0.296	ug/L
Molybdenum	<	1.43	<	1.43	<	1.43	<	1.43	1.43	ug/L
Nickel	<	2.76	<	2.63	<	2.35	<	2.7	2.76	ug/L
Selenium	<	2.81	<	2.81	<	2.81	<	2.81	2.81	ug/L
Tin	<	0.28	<	0.28	<	0.28	<	0.28	0.28	ug/L
Strontium		166		169		167		167	0.178	ug/L
Vanadium	<	2.66	<	2.17	<	1.51	<	2	2.66	ug/L
Zinc	<	2.92	<	2.46	<	2.16	<	3.03	3.03	ug/L
Cadmium		0.063		0.067	<	0.04	<	0.04	0.067	ug/L
Lead	<	0.45	<	0.33	<	0.233	<	0.34	0.45	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.167	<	0.139	<	0.129	<	0.144	0.167	ug/L

Metals Analysis Percent difference from 3rd well casing volume				
	0.5	1	2	3
Aluminum	104.58	31.67	4.17	0.00
Barium	9.30	2.07	2.07	0.00
Iron	110.91	30.00	-2.73	0.00
Manganese	38.79	24.12	6.49	0.00
Cadmium	57.50	67.50	0.00	0.00
Strontium	-0.60	1.20	0.00	0.00

General Inorganics		0.5		1.0		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Total Phosphorus		0.04		0.04		0.04		0.05	0.011	mg/L
Total Dissolved Solids		261		265		261		262	3.07	mg/L
Specific Conductance		334		336		346		340		
Carbonate alkalinity	<	0.725	<	0.725	<	0.725	<	0.725	0.725	mg/L
Total Alkalinity		62.4		60		58.6		69.6	0.725	mg/L
Bicarbonate Alkalinity		62.3		59.9		58.5		69.5	0.725	mg/L
Nitrate-Nitrite as N		0.73		0.66		0.63		0.63	0.01	mg/L
Chloride		56.7		57		55.4		56.1	0.322	mg/L
Fluoride		0.207		0.231		0.202		0.181	0.0553	mg/L
Sulfate		17.5		18.3		18		18.5	0.193	mg/L
Calcium		23		23.2		23		23.1	5.54	mg/L
Potassium		4.08		4.24		4.21		4.14	16.5	mg/L
Magnesium		4.41		4.48		4.43		4.45	5.18	mg/L
Sodium		53.8		55.6		55.3		56	14.4	mg/L
Silicon Dioxide		36.2		36.8		36.1		36.4	0.0212	mg/L

General Inorganics Percent difference from 3rd well casing volume				
	0.5	1	2	3
Total Phosphorus	-20.00	-20.00	-20.00	0.00
Total Dissolved Solids	-0.38	1.15	-0.38	0.00
Specific Conductance	-1.76	-1.18	1.76	0.00
Total Alkalinity	-10.34	-13.79	-15.80	0.00
Bicarbonate Alkalinity	-10.36	-13.81	-15.83	0.00
Nitrate-Nitrite as N	15.87	4.76	0.00	0.00
Chloride	1.07	1.60	-1.25	0.00
Fluoride	14.36	27.62	11.60	0.00
Sulfate	-5.41	-1.08	-2.70	0.00
Calcium	-0.43	0.43	-0.43	0.00
Potassium	-1.45	2.42	1.69	0.00
Magnesium	-0.90	0.67	-0.45	0.00
Sodium	-3.93	-0.71	-1.25	0.00
Silicon Dioxide	-0.55	1.10	-0.82	0.00

< indicates below detection limit

Location	Date Sampled
LAO-3A	4/25/02

Metals Analysis		0.5		1		2		3	
Analyte Desc	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Std Uom
Silver	<	0.197	<	0.197	<	0.197	<	0.197	ug/L
Aluminum		726		275		253		149	ug/L
Arsenic	<	4.57		5.12	<	4.57	<	4.57	ug/L
Boron	<	43.8	<	44.9	<	46.8	<	43.8	ug/L
Barium		51.6		50.3		49.6		48.6	ug/L
Beryllium	<	0.203	<	0.203	<	0.203	<	0.203	ug/L
Cobalt		7.04	<	1.47	<	1.52	<	0.295	ug/L
Chromium	<	4.52	<	3.91	<	3.8	<	2.8	ug/L
Copper	<	2.67	<	2.67	<	2.67	<	2.67	ug/L
Iron		315		122		105		91.9	ug/L
Manganese	<	6.03	<	2.94	<	2.94	<	2.94	ug/L
Molybdenum		2510		2500		2460		2470	ug/L
Nickel	<	2.12	<	1.33	<	1.33	<	0.743	ug/L
Selenium	<	3.09	<	3.09	<	3.09	<	3.09	ug/L
Tin	<	2.4	<	2.4	<	2.4	<	2.4	ug/L
Strontium		129		129		127		122	ug/L
Vanadium	<	4.74	<	4.25	<	4.1	<	3.7	ug/L
Zinc	<	4.57	<	4.17	<	3.33	<	2.81	ug/L
Cadmium	<	0.099	<	0.165	<	0.069	<	0.05	ug/L
Lead	<	0.353	<	0.132	<	0.125	<	0.079	ug/L
Antimony	<	0.137	<	0.127	<	0.125	<	0.186	ug/L
Thallium	<	0.017	<	0.014	<	0.014	<	0.016	ug/L

Metals Analysis Percent difference from 3rd well casing volume	0.5	1	2	3
Aluminum	387.25	84.56	69.80	0.00
Barium	6.17	2.06	2.06	0.00
Cobalt	2286.44	398.31	415.25	0.00
Iron	242.76	32.75	14.25	0.00
Molybdenum	1.62	1.21	-0.40	0.00
Strontium	0.28	0.28	0.20	0.00

General Inorganics									
Analyte Desc	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Symbol	Std Result	Std Uom
Total Phosphorus		0.16		0.17		0.15		0.15	mg/L
Total Dissolved Solids		211		216		220		220	mg/L
Specific Conductance		255		252		260		260	uS/cm
Carbonate alkalinity	<	0.725	<	0.725	<	0.725	<	0.725	mg/L
Total Alkalinity		93.5		94		93.5		92.5	mg/L
Bicarbonate Alkalinity		93.3		93.8		93.3		92.1	mg/L
Nitrate-Nitrite as N		1.3		1.29		1.29		1.3	mg/L
Chloride		13.1		13.1		13.3		18.4	mg/L
Fluoride		0.745		0.732		0.704		0.227	mg/L
Sulfate		25.6		25.5		25.5		25.3	mg/L
Hardness		70.9		70.3		70.8		67.5	mg/L
pH		7.12		7.16		7.17		7.19	
Calcium		20.2		20.1		20.2		19.4	mg/L
Potassium		5.93		5.75		5.77		5.46	mg/L
Magnesium		4.96		4.9		4.94		4.76	mg/L
Sodium		36.6		36.8		37.4		33.5	mg/L
Silicon Dioxide		49.7		49.8		51.8		48.7	mg/L

General Inorganics Percent difference from 3rd well casing volume	0.5	1	2	3
Total Phosphorus	6.67	13.33	0.00	0.00
Total Dissolved Solids	-4.09	-1.82	0.00	0.00
Specific Conductance	-1.92	-3.08	0.00	0.00
Total Alkalinity	1.08	1.62	1.08	0.00
Bicarbonate Alkalinity	1.30	1.85	1.30	0.00
Nitrate-Nitrite as N	0.00	-0.77	-0.77	0.00
Chloride	-28.80	-28.80	-27.72	0.00
Fluoride	228.19	222.47	210.13	0.00
Sulfate	1.19	0.79	0.79	0.00
Hardness	5.04	4.15	4.89	0.00
pH	-0.97	-0.42	-0.28	0.00
Calcium	4.12	3.61	4.12	0.00
Potassium	8.61	5.31	5.68	0.00
Magnesium	4.20	2.94	3.78	0.00
Sodium	9.25	9.85	11.64	0.00
Silicon Dioxide	2.05	2.26	6.37	0.00

*< indicates below detection limit

Location	Date sampled									
LAO-3A	6/5/02									
Metals Analysis		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Silver	<	0.835	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		225		105		104		119	14.7	ug/L
Arsenic	<	3.45	<	3.43	<	3.78	<	2.27	3.78	ug/L
Boron	<	36.9	<	38.2	<	34	<	36.2	38.2	ug/L
Barium		44.9		43.5		43.4		43	0.222	ug/L
Beryllium	<	0.158	<	0.158	<	0.158	<	0.158	0.158	ug/L
Cobalt	<	3.42	<	2.76	<	2.71	<	3.93	3.93	ug/L
Chromium	<	3.85	<	3.75	<	3.66	<	3.83	3.85	ug/L
Copper	<	1.39	<	1.39	<	1.39	<	1.39	1.39	ug/L
Iron		90.3	<	42.3	<	47.9	<	49.3	49.3	ug/L
Manganese	<	3.25	<	0.754	<	0.489	<	0.383	3.25	ug/L
Molybdenum		2130		2110		2120		2100	1.43	ug/L
Nickel	<	0.69	<	0.69	<	1.1	<	0.69	1.1	ug/L
Selenium	<	2.81	<	2.81	<	2.81	<	2.81	2.81	ug/L
Tin	<	0.28	<	0.28	<	0.28	<	0.28	0.28	ug/L
Strontium		118		116		116		114	0.178	ug/L
Vanadium	<	4.43	<	4.43	<	4.43	<	4.26	4.43	ug/L
Zinc		5.38	<	4.56	<	4.66	<	4.27	4.66	ug/L
Cadmium	<	0.04	<	0.04	<	0.04	<	0.04	0.04	ug/L
Lead	<	0.321	<	0.198	<	0.128	<	0.201	0.321	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.256	<	0.114	<	0.054	<	0.058	0.256	ug/L

Metals Analysis Percent difference from 3rd well casing volume				
	0.5	1	2	3
Aluminum	89.08	-11.76	-12.61	0.00
Barium	4.42	0.93	0.93	0.00
Zinc	26.00	0.00*	0.00*	0.00
Iron	83.16	-14.20	-2.84	0.00
Molybdenum	1.43	0.48	0.95	0.00
Strontium	0.19	0.10	0.10	0.00

General Inorganics		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Total Phosphorus		0.2		0.2		0.18		0.24	0.011	mg/L
Total Dissolved Solids		232		233		236		229	3.07	mg/L
Specific Conductance		238		229		237		226		
Carbonate alkalinity	<	0.725	<	0.725	<	0.725	<	0.725	0.725	mg/L
Total Alkalinity		81.6		69.6		84		79.2	0.725	mg/L
Bicarbonate Alkalinity		81.4		69.4		83.8		78.9	0.725	mg/L
Nitrate-Nitrite as N		0.72		0.74		0.73		0.73	0.01	mg/L
Chloride		9.65		9.81		9.88		10	0.322	mg/L
Fluoride		0.652		0.655		0.7		0.735	0.0553	mg/L
Sulfate		14.4		14.2		14.1		14.2	0.193	mg/L
Calcium		19.1		19.3		19.5		19.1	5.54	mg/L
Potassium		5.54		5.7		5.95		5.96	16.5	mg/L
Magnesium		4.8		4.86		4.88		4.77	5.18	mg/L
Sodium		33.7		34.1		34.6		33.6	14.4	mg/L
Silicon Dioxide		53.5		53.5		54.2		53	0.0212	mg/L

General Inorganics Percent difference from 3rd well casing volume				
	0.5	1	2	3
Total Phosphorus	-16.67	-16.67	-25.00	0.00
Total Dissolved Solids	1.31	1.75	3.06	0.00
Specific Conductance	5.31	1.33	4.87	0.00
Total Alkalinity	3.03	-12.12	6.06	0.00
Bicarbonate Alkalinity	3.17	-12.04	6.21	0.00
Nitrate-Nitrite as N	-1.37	1.37	0.00	0.00
Chloride	-3.50	-1.90	-1.20	0.00
Fluoride	-11.29	-10.88	-4.76	0.00
Sulfate	1.41	0.00	-0.70	0.00
Calcium	0.00	1.05	2.09	0.00
Potassium	-7.05	-4.36	-0.17	0.00
Magnesium	0.63	1.89	2.31	0.00
Sodium	0.30	1.49	2.98	0.00
Silicon Dioxide	0.94	0.94	2.26	0.00

< indicates below detection limit

Location	Date sampled
MCO-5	5/30/02

Analyte	Symbol	0.5 Result	Symbol	1 Result	Symbol	2 Result	Symbol	3 Result	MDL	Units
Silver	<	0.835	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		207	<	36		81.1		77.3	36	ug/L
Arsenic	<	2.31	<	2.24	<	2.24	<	2.24	2.24	ug/L
Boron		101		105		99.7		98.1	4.88	ug/L
Barium		106		103		107		103	0.222	ug/L
Beryllium	<	0.158	<	0.158	<	0.158	<	0.158	0.158	ug/L
Cobalt	<	0.541	<	2.46	<	0.541	<	0.541	2.46	ug/L
Chromium	<	1.2	<	1.06	<	1.24	<	1.49	1.49	ug/L
Copper	<	2.41	<	1.46	<	1.75	<	2.01	2.41	ug/L
Iron		100	<	33.3	<	38.4	<	23.8	38.4	ug/L
Manganese	<	1.71	<	0.526	<	0.374	<	0.296	1.71	ug/L
Molybdenum		80.3		78.5		83.1		81.2	1.43	ug/L
Nickel		5.27		5.6		5.34	<	4.84	0.69	ug/L
Selenium	<	2.81	<	3.8	<	2.81	<	2.81	3.8	ug/L
Tin	<	0.28	<	0.28	<	0.28	<	0.28	0.28	ug/L
Strontium		158		155		163		156	0.178	ug/L
Vanadium	<	0.867	<	0.606	<	0.77	<	0.923	0.867	ug/L
Zinc	<	4.37	<	4.16	<	4.03		5.24	4.37	ug/L
Cadmium	<	0.04	<	0.04	<	0.04	<	0.04	0.04	ug/L
Lead	<	0.077	<	0.067	<	0.054	<	0.05	0.077	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.02	<	0.02	<	0.02	<	0.023	0.02	ug/L

Metals Analysis

Percent difference from 3rd well casing volume

	0.5	1	2	3
Aluminum	167.79	-53.43	4.92	0.00
Barium	2.91	3.88	3.88	0.00
Boron	2.96	7.03	1.63	0.00
Iron	320.17	39.92	61.34	0.00
Molybdenum	-1.11	-3.33	2.34	0.00
Nickel	8.88	15.70	10.33	0.00
Strontium	1.28	-0.64	4.49	0.00

General Inorganics

Analyte	Symbol	0.5 Result	Symbol	1 Result	Symbol	2 Result	Symbol	3 Result	MDL	Units
Total Phosphorus	<	0.011		0.03		0.02		0.02	0.011	mg/L
Total Dissolved Solids		354		357		355		356	3.07	mg/L
Specific Conductance		435		426		426		417		
Carbonate alkalinity	<	1.45	<	1.45	<	1.45	<	1.45	1.45	mg/L
Total Alkalinity		171		192		178		187	1.45	mg/L
Bicarbonate Alkalinity		170		191		177		187	1.45	mg/L
Nitrate-Nitrite as N		3.4		3.4		3.3		3.69	0.05	mg/L
Chloride		19.5		19.2		18.9		19.1	0.0644	mg/L
Fluoride		0.965		0.949		0.96		0.934	0.0553	mg/L
Sulfate		56.8		56.4		56.4		56.2	0.386	mg/L
Calcium		42.4		42.2		43.1		43.2	5.54	mg/L
Potassium		15		14.7		14.8		15	16.5	mg/L
Magnesium		3.65		3.63		3.69		3.75	5.18	mg/L
Sodium		66.4		66		66.6		67.9	14.4	mg/L
Silicon Dioxide		36.9		36.5		37.1		36.6	0.0212	mg/L

General Inorganics

Percent difference from 3rd well casing volume

	0.5	1	2	3
Total Phosphorus	-45.00	50.00	0.00	0.00
Total Dissolved Solids	-0.56	0.28	-0.28	0.00
Specific Conductance	4.32	2.16	2.16	0.00
Total Alkalinity	-8.56	2.67	-4.81	0.00
Bicarbonate Alkalinity	-9.09	2.14	-5.35	0.00
Nitrate-Nitrite as N	-7.86	-7.86	-10.57	0.00
Chloride	2.09	0.52	-1.05	0.00
Fluoride	3.32	1.61	2.78	0.00
Sulfate	1.07	0.36	0.36	0.00
Calcium	-1.85	-2.31	-0.23	0.00
Potassium	0.00	-2.00	-1.33	0.00
Magnesium	-2.67	-3.20	-1.60	0.00
Sodium	-2.21	-2.80	-1.91	0.00
Silicon Dioxide	0.82	-0.27	1.37	0.00

< indicates below detection limit

Location	Date
MCO-6	5/29/02

Metals Analysis		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Silver	<	0.835	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		103		47.3		45.6		53.5	14.7	ug/L
Arsenic	<	2.24	<	2.24	<	2.24	<	2.24	2.24	ug/L
Boron		98.4		98.7		103		102	4.88	ug/L
Barium		105		103		104		105	0.222	ug/L
Beryllium	<	0.158	<	0.158	<	0.158	<	0.158	0.158	ug/L
Cobalt	<	3.03	<	3.15	<	2.82	<	2.65	3.15	ug/L
Chromium	<	1.03	<	0.941	<	0.763	<	0.995	1.03	ug/L
Copper	<	2.33	<	1.61	<	1.44	<	2.05	2.33	ug/L
Iron		54.4	<	19.9	<	14.5	<	24.1	24.1	ug/L
Manganese	<	2.32	<	0.372	<	0.296	<	0.488	2.32	ug/L
Molybdenum		88.7		87.1		88		89.9	1.43	ug/L
Nickel		5.43		5.76		5.52		5.62	0.69	ug/L
Selenium	<	2.92	<	2.81	<	2.81	<	2.81	2.92	ug/L
Tin	<	0.338	<	0.28	<	0.28	<	0.293	0.338	ug/L
Strontium		163		160		162		164	0.178	ug/L
Vanadium	<	0.861	<	0.693	<	0.874	<	0.916	0.916	ug/L
Zinc		5.94	<	4.91	<	4.17		6.27	4.91	ug/L
Cadmium	<	0.39	<	0.05	<	0.04	<	0.04	0.39	ug/L
Lead	<	0.189	<	0.2	<	0.081	<	0.062	0.189	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.02	<	0.02	<	0.02	<	0.02	0.02	ug/L

Metals Analysis ifference from 3rd well casing volume	0.5	1	2	3
Aluminum	92.52	-11.59	-14.77	0.00
Barium	0.00	-1.90	-0.95	0.00
Boron	-3.53	-3.24	0.98	0.00
Iron	125.73	0.00	0.00	0.00
Molybdenum	-1.33	-3.11	-2.11	0.00
Nickel	-3.38	2.49	-1.78	0.00
Strontium	-0.61	-2.44	-1.22	0.00
Zinc	-5.26	0.00	0.00	0.00

General Inorganics		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Total Phosphorus		0.05		0.03		0.04		0.02	0.011	mg/L
Total Dissolved Solids		345		350		336		356	3.07	mg/L
Specific Conductance		420		423		426		430		
Carbonate alkalinity		1.49	<	0.725	<	0.725	<	0.725	0.725	mg/L
Total Alkalinity		160		68		80		165	0.725	mg/L
Bicarbonate Alkalinity		158		67.3		79.6		164	0.725	mg/L
Nitrate-Nitrite as N		3.4		3.35		3.4		3.72	0.05 (0.03)	mg/L
Chloride		19.8		18.5		19.8		19	0644 (0.032	mg/L
Fluoride		1.07		1.08		1.08		1.09	0.0553	mg/L
Sulfate		55.4		55.4		55		55.3	0.386	mg/L
Calcium		39.6		39.4		39.4		39.9	5.54	mg/L
Potassium		16.3		16.1		16.1		16.6	16.5	mg/L
Magnesium		3.89		3.87		3.88		3.99	5.18	mg/L
Sodium		67.8		67.9		67.6		69.9	14.4	mg/L
Silicon Dioxide		35.8		35.6		35.6		35.5	0.0212	mg/L

General Inorganics ifference from 3rd well casing volume	0.5	1	2	3
Total Phosphorus	150.00	50.00	100.00	0.00
Total Dissolved Solids	-3.09	-1.69	-5.62	0.00
Specific Conductance	-2.33	-1.63	-0.93	0.00
Total Alkalinity	-3.03	-58.79	-51.52	0.00
Bicarbonate Alkalinity	-3.66	-58.96	-51.46	0.00
Nitrate-Nitrite as N	-82.11	-82.37	-82.11	0.00
Chloride	4.21	-2.63	4.21	0.00
Fluoride	-1.83	-0.92	-0.92	0.00
Sulfate	0.18	0.18	-0.54	0.00
Calcium	-0.75	-1.25	-1.25	0.00
Potassium	-1.81	-3.01	-3.01	0.00
Magnesium	-2.51	-3.01	-2.76	0.00
Sodium	-3.00	-2.86	-3.29	0.00
Silicon Dioxide	0.85	0.28	0.28	0.00

< indicates below detection limit

Location	Date sampled
MCO-7	6/5/02

Metals Analysis		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Silver	<	0.835	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		989		2300		2150		459	14.7	ug/L
Arsenic	<	2.24	<	2.24	<	2.24	<	2.24	2.24	ug/L
Boron		94.9		93.6		93		152	4.88	ug/L
Barium		193		202		199		190	0.222	ug/L
Beryllium	<	0.158	<	0.158	<	0.158	<	0.158	0.158	ug/L
Cobalt	<	0.541	<	0.541	<	0.541	<	0.541	0.541	ug/L
Chromium	<	1.05	<	1.36	<	1.5	<	0.817	0.503	ug/L
Copper	<	2.8	<	2.69	<	2.38	<	2.23	1.39	ug/L
Iron		478		1140		1060		241	12.6	ug/L
Manganese	<	7.67		17.6		15.8	<	3.32	0.296	ug/L
Molybdenum		82.9		81.7		80.5		80	1.43	ug/L
Nickel		5.74		5.53		5.45		5.72	0.69	ug/L
Selenium	<	2.81	<	2.81	<	2.81	<	2.81	2.81	ug/L
Tin	<	0.28	<	0.28	<	0.28	<	0.28	0.28	ug/L
Strontium		144		147		145		143	0.178	ug/L
Vanadium	<	3.15	<	4.25	<	4.11	<	2.5	0.606	ug/L
Zinc		11		12		10.6		7.77	0.883	ug/L
Cadmium		0.283		0.223		0.185		0.105	0.04	ug/L
Lead	<	0.822	<	1.31	<	1.32	<	0.299	0.05	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.026	<	0.036	<	0.035	<	0.025	0.02	ug/L

Metals Analysis ifference from 3rd well casing volume	0.5	1	2	3
Aluminum	115.47	401.09	368.41	0.00
Boron	-37.57	-38.42	-38.82	0.00
Barium	1.58	6.32	4.74	0.00
Cadmium	169.52	112.38	76.19	0.00
Iron	98.34	373.03	339.83	0.00
Molybdenum	3.63	2.13	0.63	0.00
Nickel	0.35	-3.32	-4.72	0.00
Strontium	0.70	2.80	1.40	0.00
Zinc	41.57	54.44	36.42	0.00

General Inorganics		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Total Phosphorus		0.25		0.23		0.28		0.22	0.011	mg/L
Total Dissolved Solids		201		327		335		333	3.07	mg/L
Specific Conductance		441		424		427		440		
Carbonate alkalinity	<	0.725	<	0.725	<	0.725	<	0.725	0.725	mg/L
Total Alkalinity		84		108		106		103	0.725	mg/L
Bicarbonate Alkalinity		83.8		108		105		103	0.725	mg/L
Nitrate-Nitrite as N		6		5.95		5.9		5.9	0.05	mg/L
Chloride		21.9		22		21.4		22.1	0.0644	mg/L
Fluoride		1.28		1.26		1.25		1.28	0.0553	mg/L
Sulfate		35.8		35.8		36.1		36.1	0.193	mg/L
Calcium		22.5		22.8		22.1		22.3	5.54	mg/L
Potassium		17.2		17.4		17.3		16.8	16.5	mg/L
Magnesium		5.21		5.28		5.17		5.16	5.18	mg/L
Sodium		77		77.9		77		77.7	14.4	mg/L
Silicon Dioxide		37.1		39.7		38		39.2	0.0212	mg/L

General Inorganics ifference from 3rd well casing volume	0.5	1	2	3
Total Phosphorus	13.64	4.55	27.27	0.00
Total Dissolved Solids	-39.64	-1.80	0.60	0.00
Specific Conductance	0.23	-3.64	-2.95	0.00
Total Alkalinity	-18.45	4.85	2.91	0.00
Bicarbonate Alkalinity	-18.64	4.85	1.94	0.00
Nitrate-Nitrite as N	1.69	0.85	0.00	0.00
Chloride	-0.90	-0.45	-3.17	0.00
Fluoride	0.00	-1.56	-2.34	0.00
Sulfate	-0.83	-0.83	0.00	0.00
Calcium	0.90	2.24	-0.90	0.00
Potassium	2.38	3.57	2.98	0.00
Magnesium	0.97	2.33	0.19	0.00
Sodium	-0.90	0.26	-0.90	0.00
Silicon Dioxide	-5.36	1.28	-3.06	0.00

Location	Date Sampled
CDBO-6	5/31/02

Metals Analysis		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Silver	<	0.835	<	0.835	<	0.835	<	0.835	0.835	ug/L
Aluminum		3680		3570		2720		5300	14.7	ug/L
Arsenic	<	2.69	<	2.24	<	2.24	<	2.24	2.69	ug/L
Boron	<	37.1	<	41.6	<	40.4	<	38.3	41.6	ug/L
Barium		95.2		106		98.9		110	0.222	ug/L
Beryllium	<	0.222	<	0.176	<	0.158	<	0.289	0.289	ug/L
Cobalt	<	0.541		7.09	<	0.541		6.39	0.541	ug/L
Chromium	<	1.58	<	1.74	<	1.38	<	2.53	2.53	ug/L
Copper	<	1.86	<	1.99	<	1.48	<	2.39	2.39	ug/L
Iron		1970		1810		1360		2800	12.6	ug/L
Manganese		32.5		23.1		16.8		24.9	0.296	ug/L
Molybdenum	<	1.43	<	1.43	<	1.43	<	1.43	1.43	ug/L
Nickel	<	0.704	<	2.71	<	0.69	<	2.67	2.71	ug/L
Selenium	<	2.81	<	2.81	<	2.81	<	2.81	2.81	ug/L
Tin	<	0.28	<	0.28	<	0.28	<	0.28	0.28	ug/L
Strontium		94.9		98.9		94.4		98	0.178	ug/L
Vanadium		6.8		7.08		6.26		8.37	0.606	ug/L
Zinc		12.5		12		20		17.2	0.883	ug/L
Cadmium	<	0.194	<	0.213	<	0.108	<	0.179	0.213	ug/L
Lead		2.28		2.34	<	1.51		2.66	1.51	ug/L
Antimony	<	3.26	<	3.26	<	3.26	<	3.26	3.26	ug/L
Thallium	<	0.029	<	0.053	<	0.035	<	0.108	0.108	ug/L

Metals Analysis Percent difference from 3rd well casing volume				
	0.5	1	2	3
Aluminum	-30.57	-32.64	-48.68	0.00
Barium	-13.45	-10.09	-10.09	0.00
Cobalt	-91.53	10.95	-91.53	0.00
Iron	-29.64	-35.36	-51.43	0.00
Manganese	30.52	-7.23	-32.53	0.00
Strontium	-3.16	0.92	-3.67	0.00
Vanadium	-18.76	-15.41	-25.21	0.00
Zinc	-27.33	-30.23	16.28	0.00
Lead	-14.29	-12.03	-43.23	0.00

General Inorganics		0.5		1		2		3		
Analyte	Symbol	Result	Symbol	Result	Symbol	Result	Symbol	Result	MDL	Units
Total Phosphorus		0.12		0.1		0.11		0.13	0.011	mg/L
Total Dissolved Solids		193		185		187		205	3.07	mg/L
Specific Conductance		161		168		154		152		
Carbonate alkalinity	<	1.45	<	1.45	<	1.45	<	1.45	1.45	mg/L
Total Alkalinity		72		73		72		62.4	1.45	mg/L
Bicarbonate Alkalinity		71.9		71.9		72.9		62.3	1.45	mg/L
Nitrate-Nitrite as N		0.14		0.14		0.13		0.13	0.01	mg/L
Chloride		14.8		14.7		15.2		15.3	0.0322	mg/L
Fluoride		0.207		0.208		0.214		0.228	0.0553	mg/L
Sulfate		9.6		9.19		9.12		9.16	0.193	mg/L
Calcium		15.2		14.8		14.5		14.2	5.54	mg/L
Potassium		2.3		2.34		2.47		2.41	16.5	mg/L
Magnesium		3.48		3.39		3.38		3.19	5.18	mg/L
Sodium		21.6		21.5		22.4		22.8	14.4	mg/L
Silicon Dioxide		67.4		65.6		68		58.7	0.0212	mg/L

General Inorganics Percent difference from 3rd well casing volume				
	0.5	1	2	3
Total Phosphorus	-7.69	-23.08	-15.38	0.00
Total Dissolved Solids	-5.85	-9.76	-8.78	0.00
Specific Conductance	5.92	10.53	1.32	0.00
Total Alkalinity	15.38	16.99	15.38	0.00
Bicarbonate Alkalinity	15.41	15.41	17.01	0.00
Nitrate-Nitrite as N	7.69	7.69	0.00	0.00
Chloride	-3.27	-3.92	-0.65	0.00
Fluoride	-9.21	-8.77	-6.14	0.00
Sulfate	4.80	0.33	-0.44	0.00
Calcium	7.04	4.23	2.11	0.00
Potassium	-4.56	-2.90	2.49	0.00
Magnesium	9.09	6.27	5.96	0.00
Sodium	-5.26	-5.70	-1.75	0.00
Silicon Dioxide	14.82	11.75	15.84	0.00

< indicates below detection limit